UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

No. 96-1337

Decided December 30, 1997

HOWARD A. FROMSON,

Plaintiff-Appellant,

—v.—

ANITEC PRINTING PLATES, INC.,

Defendant-Appellee,

—and—

JAMES R. SULLIVAN and THOMAS P. RORKE,

Defendants-Appellees.

Appealed from the United States District Court for the District of Massachusetts. Judge Ponsor.

AFFIRMED IN PART, REVERSED IN PART.

JOHN E. LYNCH, Felfe & Lynch, of New York, New York, argued for the plaintiff-appellant. With him on the brief was Alfred H. Hemingway, Jr.

WILLIAM F. DUDINE, JR., Darby & Darby, P.C., of New York, argued for defendant-appellee Anitec Printing Plates, Inc. With him on the brief were S. Peter Ludwig and Robert C. Sullivan, Jr. Of counsel was Michael J. Doyle, International Paper Co., of Tuxedo, New York.

ARTHUR F. DIONNE, Fishman, Dionne & Cantor, of Windsor, Connecticut, argued for defendants-appellees James R. Sullivan and Thomas P. Rorke.

Before MAYER, Chief Judge,* NEWMAN and PLAGER, Circuit Judges. Opinion for the court filed by Circuit Judge NEWMAN, in which Chief Judge MAYER and Circuit Judge PLAGER join. Separate opinion, concurring, filed by Chief Judge MAYER.

NEWMAN, *Circuit Judge*.

Howard A. Fromson appeals the decision of the United States District Court for the District of Massachusetts,[1] ruling that the process for continuously anodizing aluminum used by Anitec Printing Plates, Inc. did not infringe Fromson's United States Patent No. Re. 29,754 (the '754 patent). The court also ruled that the '754 patent was invalid on the ground of obviousness. We affirm the holding of non-infringement, and reverse the holding of invalidity.

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* Chief Judge Haldane Robert Mayer assumed the position of Chief Judge on December 25, 1997.

[1] *Fromson v. Anitec Printing Plates, Inc.*, 1996 U.S. Dist. LEXIS 21731, No. 91-30139-MAP (D. Mass. March 15, 1996).

The Patented Invention

This invention relates to an improved process for continuously anodizing aluminum, whereby certain processing problems of electrical arcing and resistance heating are relieved, resulting in improved products and procedures accompanied by more rapid and efficient commercial production.

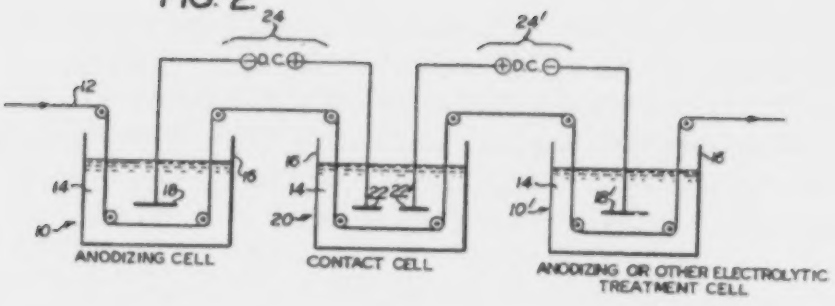
Metallic aluminum spontaneously oxidizes in air to form a thin coating of aluminum oxide upon its surface. This oxide coating protects the aluminum metal from further oxidation; however, the air-formed oxide is relatively soft, readily scratched and removed, and not of controllable durability and other properties that may be desired for specific uses. By the electrochemical process of anodization an aluminum oxide coating of controlled properties can be formed, by passing an electric current through a suitable oxygen-containing electrolyte, using the aluminum metal as the positive electrode in the circuit. Since the positive electrode is the anode, the process is called anodization. The electrolytically formed aluminum oxide can be made to varying degrees of thickness, porosity, and hardness, selected for specific end uses of the anodized product. These properties are varied by adjusting the electrolytic, physical, and chemical conditions of the process in accordance with an extensive body of technical knowledge, experience, and skill.

The Fromson '754 patent is directed to a continuous anodization process wherein aluminum sheet or wire or other shapes, called the aluminum web, is passed through a tank containing anodizing electrolyte. More rapid, continuous processing increases production and reduces costs, but the faster the speed at which the aluminum web is passed through the anodizing cells the higher the electric current must be in order to produce an oxide layer of the desired thickness. In turn, the use of high electric current densities may produce arcing when mechanical contacts are used to charge the moving aluminum web, or may produce burning when electrolytic contact cells are used.

High current densities also generate high heat at the interface where the aluminum enters the electrolyte. Due to the low resistance at the interface, surging of electrical current as well as burning of the aluminum surface and possible boiling of the electrolyte can occur as the hot metal enters the cells. Another problem in commercial anodization processes is that of resistance heating, wherein the aluminum heats up as it conducts the anodizing current. Due to any of these events, the product may be marred and unacceptable for use. This combination of long-standing problems had not been satisfactorily solved at the time of Fromson's '754 invention, despite much effort over many years.

In the prior art it was known to conduct anodization by passing the aluminum web through an initial cell called a contact cell, before it entered the anodization cell. By using a contact cell to electrolytically introduce the anodizing current into the web, surface damage done by mechanical electrical contacts, such as brushes and rollers, was eliminated. According to the '754 invention certain problems of prior contact cell processes are ameliorated by directing the current flow so that the aluminum web is passed through an anodizing cell before it enters the contact cell, using two or more separate power sources. In the first cell an initial anodized oxide coating is produced; this coating protects the aluminum from surging current as it enters the contact cell and then a second anodizing cell. Anodizing current in the first cell is introduced by way of the cathodic contact cell, while a separate source of direct current connects the contact cell and the second anodizing cell. Additional cells and current sources may also be present. Thus the '754 process uses two or more direct current power sources, the first flowing between the first cell and the contact cell, the second flowing in the opposite direction between the contact cell and the second cell. The process is illustrated in Figure 2 of the '754 patent:

FIG. 2



The claims in suit are 2, 11, and 13-15. Claim 2 is the broadest claim:

2. In a process for continuously electrolytically anodizing aluminum, the improvement which comprises introducing anodizing direct current from two or more sources in a cathodic contact cell having therein anodes connected to said sources of direct current, the aluminum having an anodized oxide coating formed thereon before entering said cell through the action of the direct current introduced in the contact cell itself.

Claim 11 specifically recites that the anodizing current is divided so as to flow through separate cross-sections of the web:

11. In a process for continuously electrolytically anodizing a moving aluminum web using the cathodic contact cell technique, the improvement which comprises introducing anodizing direct current from at least two direct current sources into said moving aluminum web into at least two cross-sections thereof, portion of the anodizing being carried out before the aluminum web enters the contact cell.

Claims 13-15 describe the process in greater detail. Claim 13, which depends from claim 11, recites that the anodizing currents flowing in two cross-sections of the web flow in opposite directions. Claims 14 and 15 both state that a porous anodic oxide coating is formed on the aluminum before it enters the contact cell. Claim 14 is illustrative:

14. Process for continuously forming a porous anodic oxide coating on aluminum which comprises:

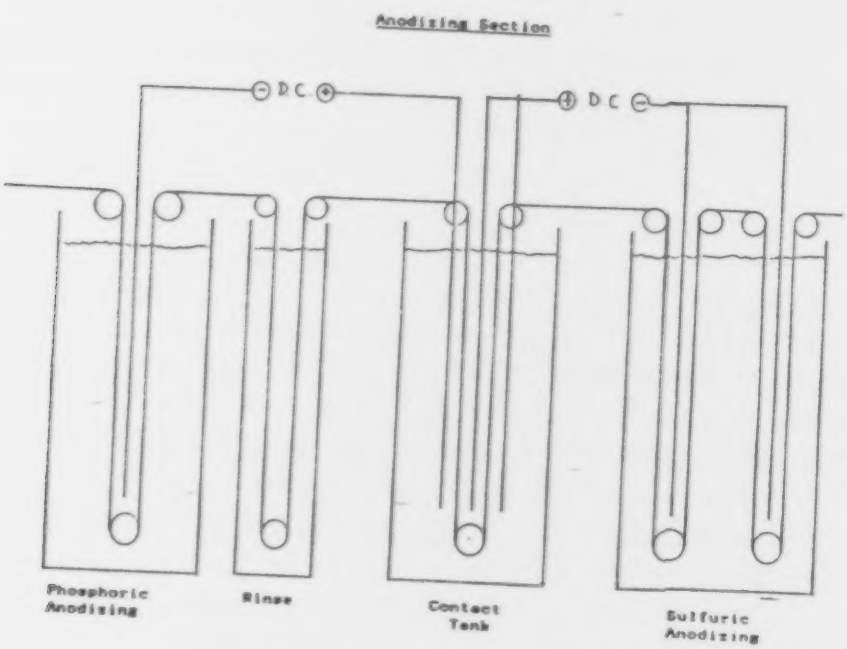
(i) passing aluminum through a cathodic contact cell, said aluminum having a portion of the thickness of said porous anodic oxide coating already formed thereon before entering said contact cell through the action of anodizing direct current from a first source of direct current introduced into said contact cell; and

(ii) further anodizing the already anodized aluminum to form the remaining portion of the thickness of the porous anodic oxide coating by introducing anodizing direct current from a second source of direct current into said already anodized aluminum in said contact cell.

I

INFRINGEMENT

The Anitec process, as illustrated in an Anitec document at trial, also uses three cells, like the illustrated Fromson embodiment, plus a rinse step:



The district court construed the '754 claims whereby the oxide-forming action in Anitec's first electrolytic cell is not included in the meaning of "anodizing" and does not produce an "anodized" coating, as those terms are used in the claims. This was the major issue in dispute.

The claims define the patent grant and set its boundaries; that is, they establish the patentee's legal rights. When technical or scientific terms in the claims require definition or explanation or understanding in the course of deciding whether the claims are infringed, it is the judicial duty to do so. *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 116 S. Ct. 1384, 1387, 38 U.S.P.Q.2D (BNA) 1461, 1463, 134 L. Ed. 2d 577 (1996) ("We hold that the construction of a patent, including terms of art within its claim, is exclusively within the province of the court.") In performing this construction, certain of the technologic facts were undisputed and others were strongly disputed insofar as technologic conclusions based thereon were material to the issue of the meaning and scope of the claims.

It was not disputed that Anitec uses a continuous electrolytic process with direct current flowing from two sources in a cathodic contact cell, and that the Anitec process forms an oxide coating on the aluminum in the first (phosphoric) cell before the aluminum enters the contact cell. Anitec conceded that its electrical connections, its cathodic contact cell, and its second (sulfuric) anodizing cell, are all within the meaning and scope of claims 2 and 11. There was no dispute that in the Anitec process the direct current was introduced from at least two sources into at least two cross-sections of the moving aluminum web, as these claims require.

However, Anitec argued that the first electrolytic cell in its process, although labelled by Anitec "Phosphoric Anodizing," is an etching and cleaning step, and that the formation of a thin layer of barrier-form aluminum oxide is not "anodization" as contemplated by the '754 patent. Anitec argued that its process does not, in the phosphoric cell, produce an "anodized oxide coating" (claim 2) or carry out a "portion of

the anodizing" (claim 11) before the aluminum web enters the contact cell. Thus the question was whether the "anodized" coating that the '754 claims require before the aluminum web enters the contact cell includes within its scope the oxide coating formed in Anitec's "phosphoric anodizing" cell. The district court viewed the question as one of claim construction under *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 34 U.S.P.Q.2D (BNA) 1321 (Fed. Cir. 1995) (en banc), aff'd, 517 U.S. 370, 116 S. Ct. 1384, 38 U.S.P.Q.2D (BNA) 1461, 134 L. Ed. 2d 577 (1996).

Claim Construction

The analysis of infringement is a two-step progression. In the first step the court construes the claims of the patent; that is, the court explains and defines any disputed technical terms and sets the scope and boundaries of the claims. In so doing the court looks principally to the patent specification and any explanatory information in the patent examination record. The court may gain understanding of the state of the art at the time the invention was made, from the prior art or from experts in the technologic field. Physical and experimental evidence may be helpful, as in this case.

The district court held that the first anodizing step of the '754 process, before the web enters the contact cell, requires not only a porous oxide coating that is electrolytically produced on an aluminum anode, but a thicker layer of porous oxide as distinguished from the thin, non-porous oxide layer that is formed in the Anitec process. The district court relied primarily on the '754 specification which describes Fromson's first anodization step as producing porous oxide, on a Papst reference discussing formation of barrier oxide, and on findings based on extrinsic evidence derived from expert testimony, demonstrative evidence, and scientific tests. Fromson disputes this claim construction, stating that Anitec admitted that anodization occurs in its first electrolytic cell, that the plain text of the '754 claims reads on the Anitec process, and that the weight of the evidence supports Fromson's interpretation of the claims and their scope.

The Specification

To determine the meaning of disputed technical terms in claims, the first resource is the patent specification of which they are a part. *Slimfold Mfg. Co. v. Kinkead Industries, Inc.*, 810 F.2d 1113, 1116, 1 U.S.P.Q.2D (BNA) 1563, 1566 (Fed. Cir. 1987) ("Claims are not interpreted in a vacuum, but are part of and are read in light of the specification.") In general, technical terms are deemed to have the same meaning in the body of the specification as in the claims. Patent specifications are written for persons of skill in the technical field, not for laymen, and often place the invention in the technologic context in which it must be understood.

The '754 specification requires that an anodized oxide coating be formed on the aluminum web before it enters into the contact cell, and teaches that the purpose of this preliminary coating is to protect the web from burning and current surging in the contact cell. The specification shows this coating to be porous oxide. While Fromson states, correctly, that a limitation from the body of the specification is not read into the claims unless the limitation is required to sustain patentability, the claims must be construed in light of the specification.

Although the '754 specification does not state that the thickness of the oxide, as the aluminum emerges from the first cell, must be greater than the thickness of naturally occurring oxide, the district court so interpreted the specification, concluding with the help of extrinsic evidence that for the coating to protect the web a thicker coating was required. The court resolved disputed testimony and documentary evidence to find that a thin barrier oxide layer enhanced burning rather than inhibited it, and that porous oxide was necessary at that stage. Thus the district court read the specification as supporting Anitec's position that since the oxide formed in its phosphoric cell is barrier oxide of under 5 nanometers in thickness, no thicker than naturally occurring oxide, the anodized oxide coating of the '754 claims can not be construed to include the Anitec process.

The Prosecution History and Prior Art

Fromson argues that since the aluminum web serves as the anode in Anitec's first cell, and an oxide layer is formed electrolytically, Anitec's process is anodization, whatever the structure of the oxide layer that is formed. The district court did not agree, despite the admission that Anitec itself consistently referred, in contemporaneous documents, to the process in the phosphoric cell as anodization. In reaching its conclusion the court relied not only on the specification, but on the prosecution of the Fromson patent as originally granted and during its reissue.

The prosecution history when a patent is reissued is part of the framework in which the patent is construed, as is the prosecution history of the original patent. Representations made and explanations presented during the reissue procedure may be relevant to interpretation of the claims. Fromson requested reissue of the patent after he learned of a Papst reference, German Patent No. 718,975, showing a two-cell anodization process in which the aluminum web enters the anodizing cell before it enters the contact cell. Fromson had originally broadly claimed this "reverse anodization" step. On reissue Fromson modified or cancelled certain broad claims, retaining the claims that contained the limitation of two or more separate direct current power sources and adding claims specific to formation of porous oxide in the first cell.

Fromson argues that the Papst reference was misapplied by the district court, for whether porous oxide was formed was not an issue in the reissue prosecution. Fromson states that he always intended to cover, and did cover in claims 2 and 11, anodizing to form either porous or non-porous oxide in the first cell. Fromson states that it was known that porous anodic oxide is formed only in a dissolving electrolyte such as sulfuric acid, and that barrier oxide was known to be formed in a non-dissolving electrolyte such as phosphoric acid. Fromson states that the Papst reference did not add to this knowledge, and that Papst did not circumscribe the Fromson teaching in the specification so as to exclude from the claims

coverage of the formation of barrier oxide. Fromson states that Papst was significant only because of its teaching of what Fromson calls "reverse anodizing," that is, the anodization before entry of the web into the contact cell.

We take note that Papst states that its process can produce barrier oxide, and that Fromson disputed whether a web bearing barrier oxide can be used in further procedures such as galvanic deposition of metal. We conclude that the reissue prosecution does not of itself limit all of Fromson's claims to porous oxide, but that Papst's (and Fromson's) recognition that barrier oxide can be formed, along with the other evidence, supports the district court's ruling.

Extrinsic Evidence

Fromson argues that when "anodized" is given its standard definition, citing Webster's Third International Dictionary, of "to subject [a metal] to action by making [it] the anode of a cell before coating with a protective or decorative film," the Anitec process fully meets this definition. Fromson states that this standard definition is all that the claims require, and is supported by the specification and prosecution history. Fromson states that since the term has a plain meaning, the district court erred in relying on extrinsic evidence to change that meaning, citing *Markman* 52 F.3d at 981, 34 U.S.P.Q.2D (BNA) at 1331 ("Extrinsic evidence is to be used for the court's understanding of the patent, not for the purpose of varying or contradicting the terms of the claims.")

Although Markman presents a useful general rule, it is adaptable to the needs of the particular case. In this case the technical experts not only aided the court's understanding of the technology, but they also provided evidence material to the interpretation of the claims. On this evidence the court enhanced the broadly stated dictionary definition of the process of anodization, with the understanding of the finer points of the technology that was provided by witnesses during the trial. Based on expert testimony, the court concluded that since not all electrolytically formed oxide coatings will pro-

tect the web as it moves into the contact cell—a fundamental purpose of the Fromson process—in the Fromson process the "anodized" coating before entry into the contact cell requires such a protective oxide.

Extrinsic evidence may be particularly helpful to the court when a specific technical aspect that is potentially of dispositive weight was not discussed in the specification or explored during the patent prosecution. This case illustrates the use of extrinsic evidence in order to determine the meaning and scope of a technical term as the term is used in the claims.

Witnesses explained that the web emerging from the first anodizing cell, unless sufficiently coated with porous oxide, would not be protected from current surging and burning in the contact cell and the second anodizing cell. Although Anitec's expert Barkman testified that it was known as early as 1958 that barrier oxide can prevent burning if precisely controlled, the district court gave greater weight to Anitec's evidence that the barrier oxide formed in Anitec's phosphoric cell did not have this effect. There was also presented analytical data that showed a thinning of the oxide layer while in the phosphoric cell, instead of a buildup of a thicker oxide layer.

There was also expert testimony and evidence based on tests varying the voltage in the phosphoric cell, showing that anodization as it occurred in the second anodization cell did not occur at the voltage used in Anitec's first cell, normally 8 volts. Other tests showed that line speed changes in Anitec's phosphoric cell did not change the oxide thickness of 4-5 nanometers, whereas line speed changes in the sulfuric cell produced proportional changes in oxide thickness, as is characteristic of the anodization process. There was evidence that the oxide formed in Anitec's first cell did not solve the burning problem, but exacerbated it. There was evidence that certain standard tests for anodization were not met for Anitec's barrier oxide (the eraser test, the bubble test, and the copper sulfate test). An expert witness testified that "anodization has

different meanings in different contexts," in explaining Anitec's use of "anodization" for its phosphoric cell as contrasted with Fromson's use of the term in the '754 process.

The district court's findings of scientific/technologic fact were material to the issue of construction of the term "anodizing." The district court concluded that the clause in claim 2 "the aluminum having an anodized oxide coating found thereon" must be construed as requiring a thicker layer of oxide than that formed in air, and that it must be porous oxide. Claim 11 was similarly construed. The court held that the barrier oxide formed in the phosphoric cell was not "an anodized surface" as the term was used in the '754 claims:

I find that in 1973 no reasonable practitioner of this process would have had the opinion that a non-porous non-adherent oxide coating, as thin as the native 5 nanometer coating found naturally in the environment, of post-phosphoric oxide, constituted an anodized surface.

The district court found that "the difference between a 1,000 or 2,000 nanometers oxide coating and a 5 nanometer oxide coating is not a difference in degree. It is a difference in kind. Something entirely different is going on." Thus the district court construed all of the claims in suit as limited to a process that produces an anodized coating in the pre-contact cell that achieves the purpose of protection against entry burning and resistance burning. The district court concluded as follows:

I conclude . . . that the terms "anodization," "anodized coating," and "anodized oxide coating" under Markman mean an electrolytically formed, adherent, porous aluminum oxide coating sufficiently thick (meaning thicker than native oxide) to, (A) protect against the burning and arcing problems addressed by the patent and optionally, (B) to provide a suitable porous base for other electrolytic treatments in the second anodizing cell such as electrophoresis, for metal plating.

Fromson readily admits that these purposes prompted his invention, but argues that the invention is not limited to these purposes, but is based on the use of a cathodic contact cell wherein an anodizing step occurs before entry into the contact

cell. Thus Fromson argues that it is irrelevant to his process whether the oxide is porous or barrier, that either one can be used in the first step of the process. However, on all of the evidence, we agree that the district court correctly construed these terms in the claims.

Claim Differentiation

Fromson argues that the doctrine of claim differentiation prohibits interpretation of the broader claims of a patent so as to import into such claims the limitations of narrower claims. *D.M.I., Inc. v. Deere & Co.*, 755 F.2d 1570, 1574, 225 U.S.P.Q. (BNA) 236, 239 (Fed. Cir. 1985). Thus Fromson argues that since claims 14 and 15 specify the formation of a porous oxide on the aluminum web before it enters the contact cell, the doctrine of claim differentiation precludes importing this "porous" limitation into claims 2, 11, and 13. Fromson argues that this well-established doctrine precludes construing claims 2, 11, and 13 to require that the anodized coating be restricted to porous oxide.

The district court limited all of the claims in suit, treating as a matter of claim construction the issue of whether the claims cover, and thus would be infringed by, barrier oxide formation. Since the court was correct in its holding that claims 2, 11, 13 are not entitled, as a matter of law, to a definition of anodizing that embraces barrier oxide formation in the pre-contact cell step, this doctrine can not, of itself, restore to Fromson's claims a scope that has been shown to be unwarranted. See *Tandon Corp. v. United States Int'l Trade Comm'n*, 831 F.2d 1017, 1024, 4 U.S.P.Q.2D (BNA) 1283, 1288 (Fed. Cir. 1987) ("Whether or not claims differ from each other, one can not interpret a claim to be broader than what is contained in the specification and claims as filed.")

Literal Infringement

The district court construed "anodized" to mean an oxide coating having specific properties, as "anodized" characterizes the aluminum before it enters into the contact cell. The

court held that the coating produced in the Anitec phosphoric cell is not "anodized" as the court construed this term. For the reasons discussed in connection with claim construction, we affirm the ruling that the Anitec process does not literally infringe the claims in suit.

This case illustrates the conceptual and practical overlap of "claim construction" as a matter of law, and the factual application of the claims to the accused process. The district court construed the '754 claims in the context of the anodized oxide formation in the phosphoric cell of the Anitec process. The extrinsic evidence on which the district court relied in its construction of the claims was geared to the infringement issue raised. Thus the court was able to limit its study to the facts placed in issue by the accused process.

We affirm the construction of the claims as correct. We do not discern clear error in the court's application of the claims, as construed, to the accused process.

The Doctrine of Equivalents

Infringement may be found under the doctrine of equivalents, although the claims as construed do not literally read on the accused process, if the accused process contains the same or equivalent elements or steps as the patented process. *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, ___ U.S. ___, ___, 137 L. Ed. 2d 146, 117 S. Ct. 1040, 1054, 41 U.S.P.Q.2D (BNA) 1865, 1875 (1997). Thus infringement under the doctrine of equivalents may lie although the process is not within the literal scope of the claims as correctly construed.

Applying the criteria of *Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 339 U.S. 605, 85 U.S.P.Q. (BNA) 328, 94 L. Ed. 1097, 70 S. Ct. 854 (1950), as modified in Warner-Jenkinson, the accused process must perform substantially the same steps as the patented process, in substantially the same way, to obtain the same result. Equivalency is a question of fact, and findings thereon are reviewed for clear error. Clear error exists when "the reviewing court on the entire evidence

is left with the definite and firm conviction that a mistake has been committed." *Anderson v. City of Bessemer City*, 470 U.S. 564, 573, 84 L. Ed. 2d 518, 105 S. Ct. 1504 (1985).

Fromson argues that on the district court's claim construction there is infringement under the doctrine of equivalents. Fromson points out that the barrier oxide produced in Anitec's phosphoric cell is not natural oxide but the product of anodization, and that because it is harder and more adherent and protective than natural oxide it serves the function of an anodized oxide. Thus Fromson argues that the Anitec barrier oxide is equivalent to the Fromson porous oxide, for both are products of the same kind of electrolytic process and serve the same function in substantially the same way, to achieve the same result.

The district court did not agree. The court considered all of the evidence concerning the patented and the accused oxide coatings, and determined that the Anitec oxide formed in the phosphoric cell did not have the same properties as the Fromson oxide formed in the sulfuric cell, and did not serve the same purpose and solve the same problem. The court found that the primary function of the phosphoric cell in Anitec's process was to clean and condition the aluminum, not to provide an anodized layer to protect the web from surges or burning at high current densities. The court found that the thin barrier oxide coating initially formed on the Anitec web did not provide such protection, unlike Fromson's thicker porous coating. Thus the court found that there was not equivalency between the initial Anitec oxide and the "anodized coating" required by the '754 claims, in that the functions were not substantially the same. This finding has not been shown to be clearly erroneous.

The decision that there is not infringement under the doctrine of equivalents is affirmed.

II

VALIDITY

The district court held the '754 claims invalid on the ground that the invention would have been obvious in light of the prior art. Obviousness is a question of law based on underlying facts, *Graham v. John Deere Co.*, 383 U.S. 1, 17, 148 U.S.P.Q. (BNA) 459, 467, 15 L. Ed. 2d 545, 86 S. Ct. 684 (1966). Included are the factual questions of the scope and content of the prior art, the differences between the claimed invention and the prior art, the level of ordinary skill in the field of the invention, and any objective evidence of unobviousness. *Graham*, 383 U.S. at 17-18, 148 U.S.P.Q. (BNA) at 467; *Glaverbel Societe Anonyme v. Northlake Mktg. & Supply, Inc.*, 45 F.3d 1550, 1555, 33 U.S.P.Q.2D (BNA) 1496, 1499 (Fed. Cir. 1995). The determination of whether the subject matter as a whole would have been obvious to a person of ordinary skill at the time the invention was made, is reviewed for correctness as a matter of law. The underlying factual determinations are reviewed on appeal for clear error. Due consideration is given to the requirement that invalidation based on obviousness must be established by clear and convincing evidence. Id.

The parties generally agree as to the prior art and its teachings, and as to the level of ordinary skill in this field in 1972. The district court concluded that the patent was invalid "looking at Chubb, Cook, Barkman, and the other inventions that preceded this one . . . ." Fromson points out, and we must agree, that although much had been written on anodization, in this highly studied field no reference or combination of references showed or suggested the '754 process as a whole.

The Chubb reference describes producing an insulating coating of aluminum oxide on wire to be used in electrical machinery. Chubb shows a contact cell and the countercurrent movement of the electric current, and teaches that "the electric current may be supplied to the conductor to be treated either before or after it has received an insulating coating and

also in either the direction in which the wire is moving or in the opposite direction . . . ." This is quite different from the Fromson process. Other distinctions are that Chubb involves a single power source and shows only non-dissolving electrolytes (to produce a non-porous coating); a boilerplate statement that other "suitable liquids" can be used is insufficiently specific to include dissolving electrolytes such as are used by Fromson.

In the Barkman reference the contact cell precedes the preanodizing cell in the processing of the web, a process shown to have disadvantages that were remedied in the Fromson process. Although Anitec argues that Fromson's change in the sequence of steps is simply an "obvious choice," the choice apparently escaped Barkman, along with the benefits reported by Fromson. The Cook reference divides the anodizing cell into two or more compartments in order to avoid burning, but does not suggest use of an anodizing procedure before entry into the contact cell. The other references before the district court also contain differences from Fromson's process. They show the extensive effort expended in this area of technology, but none shows the process of the '754 patent.

That an inventor has probed the strengths and weaknesses of the prior art and discovered an improvement that escaped those who came before is indicative of unobviousness, not obviousness. The district court did not correctly apply the law of obviousness, for there is no suggestion or teaching in the prior art to select from the various known procedures and combine specific steps, along with a new electrical structure, in the way that is described and claimed by Fromson. The judgment of invalidity is reversed.

Damages

Damages and other issues raised on appeal are mooted by our affirmance of the judgment of noninfringement.

Costs

No costs.

AFFIRMED IN PART, REVERSED IN PART

MAYER, Chief Judge, *concurring*.

I write separately to emphasize the incompleteness of this court's Markman[1] dissertation on the use of extrinsic evidence in construing patent claims. Federal Rule of Evidence 702 says that expert testimony and evidence is admissible not only to educate but also to find facts. "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise." (Emphasis added). If there is no disagreement about the meaning of a term in a patent, even a complex one, expert testimony can come in to educate, akin to a motion for summary judgment as a matter of law on undisputed material facts. But when, as here, there is vigorous dispute and conflicting evidence about the meaning of a term, the trial judge has to make findings of fact as he decides the meaning to ascribe to the patent.

If this were truly an exercise in construing words and concepts as a matter of law, absent any factual components, Fromson might well prevail; at least he would have my vote. I "know" what anodization means from my own undergraduate studies and experiments; the concept is not difficult and I need no further education to grasp it. I happen to have a dictionary in my chambers from the era pertinent here, which would confirm my "knowledge" about anodization. Fromson appeared to use the term without limit and, not surprisingly, so proclaims; even Anitec personnel called its process by the same name. But, I am neither an expert in the field nor one of ordinary skill in the art despite how much I think I "know" about a process I once studied. Nor do my colleagues on this court or on the district court possess such expertise, and even if they did, they would have to defer to the record made in the

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[1] *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 34 U.S.P.Q.2D (BNA) 1321 (Fed. Cir. 1995) (in banc).

case. The trial judge performed his Daubert[2] duty and allowed expert testimony and other evidence, not only so that he might become better educated about the meaning of anodization, but also so that he might develop the record and find the meaning of anodization, as used in this patent, to one skilled in the art in 1973. That he has done. We are affirming his claim—construction—as a matter of law based on the facts he found from conflicting evidence, which are not clearly erroneous.

The trial court has comprehensively laid out and our opinion reviews the evidence, and it defies reason to suggest that the evidence was merely taken for its educational value. This construction is correct as a matter of law on this record, but only because of the factual predicate. This case could readily and probably would have come out differently if we were free, as some of our cases suggest, to decide the issue anew as a matter purely of law. The court's opinion, which I fully join, demonstrates that the surest way to maintain consistency and certainty in patent cases is for us to rely on the trial court's fact finding expertise and the record it makes and considers. We do a disservice if we go off on a definitional inquest of our own.

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[2] *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 125 L. Ed. 2d 469, 113 S. Ct. 2786 (1993); see also *General Elec. Co. v. Joiner*, 118 S. Ct. 512, 139 L. Ed. 2d 508, 1997 WL 764563 (U.S. 1997).

UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

No. 96-1337

Filed February 23, 1998

HOWARD A. FROMSON,

Plaintiff-Appellant,

—v.—

ANITEC PRINTING PLATES, INC., JAMES R. SULLIVAN and THOMAS P. RORKE,

Defendants-Appellees.

ORDER

A combined petition for rehearing and suggestion for rehearing in banc having been filed by the APPELLANT, and a response thereto having been invited by the court and filed by the APPELLEE, and the petition for rehearing having been referred to the panel that heard the appeal, and thereafter the suggestion for rehearing in banc and response having been referred to the circuit judges who are in regular active service.

UPON CONSIDERATION THEREOF, it is

ORDERED that the petition for rehearing be, and the same hereby is, DENIED and it is further

ORDERED that the suggestion for rehearing in banc be, and the same hereby is, DECLINED.

The mandate of the court will issue on March 2, 1998.

FOR THE COURT,

JAN HORBALY, CLERK

Dated: February 23, 1998

By /s/ ALEX VAN VEEN
Alex Van Veen
Staff Law Clerk

cc: JOHN E. LYNCH
WILLIAM F. DUDINE, JR, ARTHUR F. DIONNE

FROMSON v ANITEC PRINTING PLATES, 96-1337
(DCT—91-CV-30139)

UNITED STATES DISTRICT COURT
DISTRICT OF MASSACHUSETTS

Case No. 91-30139-MAP

HOWARD A. FROMSON,

—v.—

ANITEC PRINTING PLATES, INC., ET AL.

JUDGMENT IN A CIVIL CASE

☐ Jury Verdict. This action came before the Court for a trial by jury. The issues have been tried and the jury has rendered its verdict.

☑ Decision by Court. This action came to trial or hearing before the Court. The issues have been tried or heard and a decision has been rendered.

IT IS ORDERED AND ADJUDGED.

PER MEMORANDUM AND ORDER ENTERED March 15, 1996:

Judgment entered for defendants on all counts.

March 15, 1996	ROBERT J. SMITH, JR.
Date	*Clerk*
	/s/ [ILLEGIBLE]
	(By) Deputy Clerk

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

Civil Action No. 91-30139-MAP

March 15, 1996

HOWARD A. FROMSON,

Plaintiff

—v.—

ANITEC PRINTING PLATES, INC., ET AL

Defendants

MEMORANDUM AND ORDER

PONSOR, D.J.

On March 14, 1996, this court entered oral findings of fact and conclusions of law into the record, deciding the case in favor of the defendant. The basis of the decision was detailed in the oral findings and conclusions; it is summarized below.

In essence, the court, after making a determination as to the meaning and scope of the asserted claims and comparing these to the accused process, concluded that the plaintiff had failed to carry his burden of showing infringement by a fair preponderance of the evidence. This conclusion extended both to the claim of literal infringement and to the alternative claim of infringement by equivalents since the limitations of

the patent claims were neither exactly found in Anitec's accused process or found by way of a substantial equivalent.

In addition, the court found that the defendant had proven by clear and convincing evidence that the patent is invalid, because it was anticipated and rendered obvious in view of the prior art. In other words, regarding the '754 patent, "the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art." 35 U.S.C. § 103.

The court rejected the defendant's defense of laches and *res judicata*, and the defense that the patent was invalid because of the plaintiff's inequitable conduct.

Finally, the court stated, provisionally, that if a reviewing court should conclude that the decision with regard to patent infringement and patent invalidity were both incorrect, and that plaintiff is entitled to money damages, then the theory of damages offered by the defendant was the fairest and most reasonable. Damages would be limited both due to the plaintiff's failure to mark (as the court has previously found in allowing the motion for summary judgment of the co-defendants Sullivan and Rorke) and due to the complete absence of adequate evidence to demonstrate any willfulness on the defendant's part, if infringement were to be found. Applying the standards approved by the Federal Circuit, and positing a hypothetical arm's-length negotiation between a willing patent owner and a willing potential user taking place at the time of the infringement (assuming a reviewing court concludes that infringement occurred), the court determined that, if it had reached the issue of damages, it would have awarded plaintiff $42,500, plus a 50% enhancement for a total damage award of $63,750, with interest from the date of filing.

In conclusion, the court hereby orders entry of judgment in favor of the defendant Anitec Printing Plates, Inc. based upon the oral findings of fact and conclusions of law entered on March 14, 1996. Moreover, the court orders entry of judgment for the co-defendants Sullivan and Rorke based upon its earlier ruling on their motion for summary judgment. Obviously,

if a reviewing court concludes that the ruling on Sullivan and Rorke's motion for summary judgment is incorrect, entry of judgment in their favor would still be required based upon the court's findings of lack of infringement and invalidity.

The clerk is ordered to enter judgment for the defendants in accordance with this memorandum.

/s/ MICHAEL A. PONSOR
MICHAEL A. PONSOR
U.S. District Judge

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

Docket No. CA 91-30139
March 14, 1996, Decided

HOWARD A. FROMSON

—VS.—

ANITEC PRINTING PLATES, INC., JAMES R. SULLIVAN and THOMAS P. RORKE

Verdict in favor of defendant on all counts in the complaint.

For plaintiff: Felfe & Lynch, By: John E. Lynch, New York, NY.

For defendant: Darby & Darby, By: William F. Dudine, Jr., S. Peter Ludwig, and Robert C. Sullivan, Jr., New York, NY.

HONORABLE MICHAEL A. PONSOR, DISTRICT COURT JUDGE.

JUDGE PONSOR'S ORAL FINDINGS OF FACT AND CONCLUSIONS OF LAW

THE COURT: Please be seated. It's my intention now to make my oral findings of fact and conclusions of law on the record here. As I go through the findings and conclusions you will see me referring to various documents, and, obviously, these have not all been prepared in the last 15 or 20 minutes. I did considerable work preparing for today's hearing. But I want to underline again that I did not have my mind made up when I came out to hear the oral arguments. I have been able to put things in order after hearing the oral arguments.

As you know, I'm going to be entering a verdict in this case in favor of the defendant on all counts in the complaint.

The purpose of this presentation is to set down my findings of fact and conclusions of law, those that I have determined require me to decide the case this way.

Before I get to specifics, let me state a few preliminaries. First, I realize that it may be hard to receive what I have to say face to face; nevertheless, I think it is proper for you to hear directly from me the details of my decision.

I've told you all the bottom line ahead of time so that anyone who feels that he or she may have difficulty sitting through the reasons may leave and obtain a transcript of my remarks for private review.

I expect everyone here now to listen to what I have to say with courtesy and reserve with neither positive nor negative expressions of any kind.

I'm not, obviously, going to debate my decision with counsel. It's made. However, if I make an obvious error of fact in terms of mis-citing a date or something of that nature, I am not opposed to be being corrected.

Second, I reserve the right to smooth out and perhaps add details to these oral remarks in a written form at a later date, if necessary. I may or may not do that, but if I do, I will not, of course, change the substance of my decision nor my reasoning.

Third, please remember, a trial is not usually about who is lying or who is telling the truth, and it was certainly not about that in this case.

A trial, generally, and this case especially, is about whether the party bearing the burden of proof, here the plaintiff, Howard Fromson, has proved the case by a fair preponderance of the evidence.

In my opinion, all parties to this case, plaintiff and defendants alike, behaved with integrity and sincerity. I want to underline that. It's obvious that I'm reading from notes here as I say that, but I do want to convey personally that I believe everyone in this trial behaved with integrity and sincerity, and there was no effort on anyone's part to prevaricate or attempt to mislead the court.

I have found for the defendants simply because I found that the plaintiff's case, in view of all the evidence, was not more likely true than not true; that is simply the burden.

If the evidence is in equipoise, I must decide for the defendant. The plaintiff bears the burden of proving its case by a fair preponderance of the evidence.

This decision reflects no judgment on the personal integrity of the plaintiff or anyone else. Let me say with equal force that my decision in no way suggests that the defendant's attorneys outperformed the plaintiff's attorney. This case, which was very difficult in many ways, was tried with equal vigor and skill by both sides.

I truly cannot imagine an argument or piece of evidence that either side could have brought out to support its case or undermine its opponent's case that was not presented.

One of the great pleasures of being a trial judge is to preside over a case well tried on both sides, and this was such a case.

I will tell you in the privacy of this room that many district court judges look upon patent cases as a form of legal root canal. I certainly cannot say that in my case and in connection with this case. It has been a pleasure for me to try this case and to preside over this case both because the issues were inherently interesting, and because it was so effectively and professionally presented by both sides.

I'm now going to turn to a summary of the facts that I believe support the decision that I am making here. I want to emphasize that I am not addressing every single fact that might be adduced in defendant's favor, or that I might have considered. Given the length of the trial and the size of the record, this would be an almost endless task.

No one reviewing these findings, however, should assume, because a fact or piece of evidence is not specifically mentioned, it was not considered. I have carefully considered all the evidence in this case in making my decision.

I want to turn now to a little bit of background material from the patent, and I'm going to be using portions of the plaintiff's submissions in order to make my findings in this section.

This is a patent infringement case in which Howard A. Fromson, a Connecticut resident, sued Anitec Printing Plates, Incorporated, which will be referred to as Anitec, James R. Sullivan, who I will refer to as Sullivan, and Thomas P. Rorke, Rorke, for infringement of process claims 2, 11, 13, 14, and 15 of United States Patent No. 29754.

Anitec has two manufacturing plants in Holyoke, Massachusetts, and Sullivan and Rorke both reside in Massachusetts.

The individual defendants, as we all know, Sullivan and Rorke, obtained summary judgment prior to this trial and are not parties, active parties to the trial. Anitec was the sole defendant during the course of trial.

Trial of this case took place over three weeks in November of 1995, and my findings of facts and conclusions of law draw from the entire record of this case.

I find that the plaintiff, Mr. Fromson, who is the owner of the 754 patent, obtained his degree in economics in 1943. In 1952, after years of employment by a company that imported metal for resale, he established a company that imported non-ferrous metal, f-e-r-r-o-u-s, including aluminum, for resale in this country.

In the early 1950s Mr. Fromson learned of a German company, Metalloxyde, M-e-t-a-l-l-o-x-y-d-e, that was employing a process for continuously anodizing coiled aluminum sheets and began to import that company's anodized aluminum for resale.

Eventually, Mr. Fromson determined that his business really required local manufacturing and he established Anocoil Corporation which began continuously anodizing aluminum in Rockville, Connecticut.

His first anodizing line utilized a contact roll, an anodizing tank containing electrolytes and cathodes, which are negatively charged electrodes, and one rectifier, which is also sometimes referred to as a DC power source to anodize a continuous web of aluminum.

Problems were inherent in this process which were being addressed by the industry during this period of time. These included arcing at the face of the aluminum web in the contact roll resulting in burning of the aluminum web and even of the roll itself and some scratching of the roll. These burning and scratching problems limited the line speed of Anocoil's continuous anodizing operation.

Mr. Fromson subsequently modified Anocoil's anodizing process by replacing the contact roll with a contact cell or tank which contained an electrolyte and anodes.

This modification permitted increased line speed, but burning of the aluminum web when the aluminum entered the anodizing tank became a problem in this process because of the phenomenon of heating that arises when the current carrying the aluminum web enters the anodizing tank electrolyte.

This form of burning as applied to anodizing in its worse case manifests itself as an actual melting of the aluminum web. Even in better situations, it results in the production of an unsound oxide coating.

Two related problems were involved in increasing the production line speed, both the burning problem described above and the inherent process limitations imposed by the current-carrying capacity of the continuous aluminum web being anodized.

As will be seen, various companies and inventors were experimenting in the mid-20th Century, and even as far back as the Chubb patent at the beginning of the century, with different ways to address this problem.

Mr. Fromson theorized that if the electrode power required for anodization could be distributed in a controlled fashion simultaneously through more than one cross-section of the aluminum web, he could alleviate two problems: A, the inherent limitation arising from the uncontrolled resistance and heating of the web due solely to the electric current being put into the web, and B, the kind of burning problem encountered in using the contact cell process.

His process for employing this concept was to utilize two anodizing tanks, one contact cell, and two power sources. This process permitted simultaneously delivering controlled current to two cross-sectional areas of the aluminum web, and was the subject of a May 18, 1973 patent application.

The May 18, 1973 patent application issued on February 11, 1975 as U.S. Patent No. 3865700, which will be referred to as the 700 patent.

After issuance of the 700 patent, however, Mr. Fromson learned of a German patent given to an entity known as Papst, P-A-P-S-T. Since he believed that certain of the claims in the 700 patent were too broad in view of the Papst patent, he filed an application to re-issue the 700 patent with new claims in January of 1977, and a new replacement patent, 29754, the patent at issue in this case, was issued on September 5, 1978. That is the background for the patent.

The background of the defendant's production and the development of its process is as follows: At various times the corporate defendant has been known as Advanced Offset Plate, Incorporated, or Graphcoat, G-R-A-P-H-C-O-A-T, Incorporated, Cookson Graphics, Incorporated, and, finally, Anitec Printing Plates. The entity has been called Anitec throughout this trial for purposes of convenience.

Anitec was founded in 1972 to make and sell lithographic printing plates of anodized aluminum by the defendants, Mr.

Sullivan, who was president and the chief financial officer until his departure in 1987, and his co-defendant, Mr. Rorke, who was vice president in charge of manufacturing and technology until his departure in 1989.

When Anitec first began continuously anodizing aluminum in 1972, it obtained a license to use a patented anodizing process for a nominal royalty from Reynolds Aluminum. This was the continuous anodizing process of U.S. Patent No. 3079308 which was issued to Mr. Barkman, who was a witness in this trial.

The Barkman continuous anodizing process licensed by Anitec in 1972 and described by Mr. Barkman in his 308 patent employed a contact cell, one anodizing cell with multiple cathodes and a single power source.

From the outset, Anitec's lithographic printing plates were made of aluminum that had been anodized and subsequently treated with silicate according to Fromson's U.S. Patent 3181461.

Fromson sued Anitec for infringement on the 461 patent in 1976, and Anitec was found to have willfully infringed the Fromson 461 patent. Those proceedings were not terminated until 1986, and are referred to as the Advance case to the extent that such reference is necessary in this decision.

The citations to the Advance case are contained in the party's memoranda, but may be found at *720 F.2d 1565*, (Fed. Circuit 1983), and *755 F.2d 1549*, (Fed. Circuit 1985).

By February 1975 Anitec had altered the Barkman process by employing two power sources, one for each pair of four cathodes in the main anodizing section. Thus, two months before, even in plaintiff's view of the facts, the defendants ever knew of the Fromson patent, they were already using a modification of the Barkman patent employing two power sources.

In April of 1975, Attorney Arthur Dionne, Anitec's patent counsel, sent Rorke the abstract of several patents including the Fromson 700 patent.

The evidence as to whether Mr. Rorke read this 700 patent is essentially non-existent. Mr. Rorke did not himself recall reading them. It is possible that he may have read them, but it is, in essence, pure speculation to suggest that he did anything more than glance over the patents.

In any event, I want to find affirmatively here on a point which is hotly contested in this trial, that the Anitec process did not copy Mr. Fromson's process as a result of the receipt of the 700 patent from Mr. Dionne. This is because the Barkman process as modified by Anitec gave them everything that they needed to run their production line without any necessity to employ the Fromson process.

So I want the record to affirmatively reflect my finding that there was no copying of the Fromson patent by Anitec in its production line as a result of the receipt of a copy of the 700 patent from Mr. Dionne in 1975.

In 1978, Mr. Fromson's counsel inspected Anitec's plant in Holyoke in conjunction with what I have called the Advance case which was then in litigation, having, as I noted, been filed in 1976.

Anitec was then using precisely the process that the plaintiff now accuses as infringing the Fromson patent.

In addition, the day after Mr. Lynch, representing Fromson in that case, visited the Holyoke facility and observed the process, he had an opportunity to depose Mr. Rorke, one of the principals of Anitec, with regard to their processes.

I want to skip forward now to 1984. There's no evidence of any pertinent activity between 1978, when Mr. Lynch visited the Anitec manufacturing facility, and May of 1984, between 1978 and 1984.

In May of 1984 Mr. Fromson obtained information that suggested that a company unrelated to this litigation was using his 754 anodizing process. His counsel therefore sent letters to ten manufacturers of anodized aluminum lithographic printing plates advising them of the 754 patent and solicited comments.

Anitec's president, Sullivan, was one of the recipients of this notice and letter. The letter itself is extremely brief. It

simply notes the existence of the patent and asks if there was any comment.

Mr. Sullivan received the letter and consulted with his attorney, Mr. Dionne, about the 754 patent. At this time in 1984 the litigation, which I've called the Advance litigation, was still in process.

Mr. Dionne reviewed the 754 patent and made a recommendation that there be an alteration in the production line at Anitec in order to avoid infringing the 754 patent.

This advice was followed in the sense that one of the sulfuric anodizing tanks was changed in location in relation to the contact tank.

At this point I want to make another finding on the record, that the decision by Anitec to alter its production line by changing the configuration of the sulfuric anodizing tank was made in a good faith effort to eliminate any infringement of the 754 patent.

Although there is evidence on both sides, the stronger evidence in this case has persuaded me that the decision to leave the phosphoric anodizing tank in its position without changing it was based upon Anitec's conclusion that the process taking place in the phosphoric tank did not violate Mr. Fromson's patent. This is the explanation for why they changed the location of the sulfuric tank but not the phosphoric tank. I'll be getting into that in a little bit more detail in a moment.

At this point, however, I also want to make a finding that the response to Mr. Fromson's letter describing his 754 patent and soliciting comments, to the effect that the defendant "had no interest" in the 754 patent, was based upon the fact that the defendant had altered its production line by changing the location of the sulfuric anodizing tank and was convinced that its production line did not infringe Mr. Fromson's patent.

Since the reconfigured production line did not infringe Mr. Fromson's patent, the response that they had no interest in Mr. Fromson's patent is therefore understandable.

I want to turn now to a description of exactly what the claims are in this case and where the Court is coming out on

the important, and, indeed, the central question in this case, which is infringement.

The plaintiff charges that the defendants infringed four independent claims of the 754 patent. These are Claims 2, 11, 14, and 15.

Claim 2 reads as follows: In a process for continuously electrolytically, that's e-l-e-c-t-r-o-l-y-t-i-c-a-l-l-y, anodizing aluminum, the improvement which comprises introducing anodizing direct current from two or more sources in a cathodic, c-a-t-h-o-d-i-c, contact cell having therein anodes connected to said sources of direct current, the aluminum having an anodized oxide coating formed thereon before entering said cell through the action of the direct current introduced in the contact cell itself.

Claim No. 2 states—sorry, claim No. 11, which is the second claim which the plaintiff asserts was infringed, states as follows: In a process for continuously electrolytically anodizing a moving aluminum web using the cathodic contact cell technique, the improvement which comprises introducing anodizing direct current from at least two direct current sources into said moving aluminum web into at least two cross-sections thereof, portion of the anodizing being carried out before the aluminum web enters the contact cell.

Claim No. 14: Process for continuously forming a porous anodic oxide coating on aluminum which comprises: (i) passing aluminum through a cathodic contact cell, said aluminum having a portion of the thickness of said porous anodic oxide coating already formed thereon before entering said contact cell through the action of anodizing direct current from a first source of direct current introduced into said contact cell; and (ii) further anodizing the already anodized aluminum to form the remaining portion of the thickness of the porous anodic oxide coating by introducing anodizing direct current from a second source of direct current into said already anodized aluminum in said contact cell.

15, Claim No. 15, the final claim asserted by the plaintiff reads as follows: Process for continuously forming a porous

anodic oxide coating on an aluminum web which comprises: (i) passing said web through a first anodizing cell having therein a cathode connected to a first source of direct current; (ii) passing said web from said first anodizing cell into a cathodic contact cell having therein an anode connected to first—to said first source of direct current and a second anode connected to a second source of direct current; (iii) passing said web from said contact cell into a second anodizing cell having a cathode therein connected to said second source of direct current; and (iv) introducing anodizing direct current from said sources into said web in said contact cell thereby forming a portion of the thickness of the porous oxide coating in said first cell and the remaining portion in said second anodizing cell.

Before moving onto the Markman criteria and the task of the court, I want to briefly comment upon my interpretation of the language contained in Claims 14 and 15.

There has been a suggestion in this case that the formation of a non-porous oxide in the first phosphoric cell would infringe Claims 14 and 15 if a porous oxide were formed in the second sulfuric cell. I do not believe that is a reasonable reading of the language of Claims 14 and 15.

The reasonable reading of the language of Claims 14 and 15 requires that a porous oxide coating be formed in both the first and second cell. This conclusion is supported by careful reading of the language of Claims 14 and 15.

I want to move now to the legal standards which I must apply in rendering my decision on the issue of infringement in this case.

These claims that I have read from the 754 patent, the four claims, must be the primary focus of the litigation and of my analysis of the litigation brought by Mr. Fromson for patent infringement.

The infringed claims or the claims for infringement must be analyzed in terms of the way they are drafted in the patent before us, and not in terms of the way that Anocoil, the plaintiff's company, happens to use that patent. I recognize that

fact as part of my responsibility, and to make the record clear I want to emphasize that again.

In making my decision with regard to infringement, I am analyzing the claims as set forth in the patent and I am not focusing upon how the patent happens to be used in a particular industrial complex employed by Mr. Fromson.

Mr. Fromson has the burden of demonstrating by a fair preponderance of the evidence that defendant, Anitec, infringed the 754 claims asserted either literally or by equivalence.

To prove infringement, Mr. Fromson must show that every limitation of a patent claim is either exactly found in Anitec's accused process or found by a way of substantial equivalence.

The former infringement, if present, is termed literal infringement and the latter is termed infringement by equivalence.

Infringement, whether literal or under the Doctrine of Equivalence, is a question of fact, and in making my determination with regard to infringement, I am sitting as a fact finder; in essence, a jury of one.

The assessment of a claim of infringement is a two-step process and counsel agree upon this. First, the meaning and scope of the asserted claims must be determined. Second, these claims as construed must be compared to Anitec's accused process.

Both counsel agree that the most recent case articulately setting forth this two-step process is called *Markman, M-A-R-K-M-A-N, v Westview Instruments, Incorporated, 52 F.3d 967 at 976* (Fed. Circuit 1995.)

That case is now under review by the Supreme Court but counsel seem to agree that the articulation of the standard is not the point that's under review.

In other words, the relevant questions are: What did Fromson's patent—what did Fromson patent by the asserted process claims? And has Anitec, through the accused process, used what Mr. Fromson patented by these claims?

The determination of the scope of the claim in issue is a matter of law. This Court has the power and obligation to construe as a matter of law the meaning of language used in the patent claim.

In determining the meaning of the patent claim, the court should consider three principal sources: the claims themselves, as set forth in the patent; the specifications, as set forth in the patent, which is just a term used in patent law to describe the explanatory sections of the patent, which actually precedes the claims contained in the patent; and, three, the prosecution history.

I also am entitled as a matter of my discretion to consider secondary sources such as expert testimony and other extrinsic evidence. And I want to here note that I have exercised my discretion in this case to consider expert testimony and extrinsic evidence for the reasons that I will state in a moment. I believe that such consideration has been essential, given the slipperiness of the term "anodization."

I'm going to turn now to the first portion of the Markman task, construing the meaning and scope of the asserted claims. I said a moment ago that a problem in this case is the slipperiness of the term "anodization."

As I mentioned during the trial, Professor Hobbs and I happened to have been at Oxford at the same time, although we didn't know each other. I read English language and literature. I'm sure he was doing something more quantitative when he was at Oxford. But I do find that this case, in essence, or in many respects, boils down to Juliet's question to Romeo: "What is in a Name?" And her comment that "It is Thy Name That is My Enemy." And the enemy in this case to some extent of all the parties is the term "anodization."

I find that anodization in 1973 did have a fairly clear meaning in terms of its industrial application, and that meaning is consistent with the definition proposed by the defendants at page 15 of their memorandum.

And I conclude for reasons that I will state in a moment that the terms "anodization," "anodized coating," and "anodized oxide coating" under Markman mean an electrolytically-formed, adherent, porous aluminum oxide coating sufficiently thick (meaning thicker than native oxide) to, (A) protect against the burning and arcing problems addressed

by the patent and optionally, (B) to provide a suitable porous base for other electrolytic treatments in the second anodizing cell such as electrophoresis, e-l-e-c-t-r-o-p-h-o-r-e-s-i-s, for metal plating.

I find that in 1973 no reasonable practitioner of this process would have had the opinion that a non-porous non-adherent oxide coating, as thin as the native 5 nanometer coating found naturally in the environment, of post-phosphoric oxide constituted an anodized surface. There are several reasons for that and I want to go into them.

I have made a determination to assess the claims, the specifications, the prosecution history, and the extrinsic evidence in making a determination of the meaning and scope of the asserted claims because, as I noted, the claim containing the word anodization carries no automatic meaning.

Defendant's own expert, Professor Latanision's, himself noted that the word anodization has different meanings in different context.

I have determined that the meaning of anodization for purposes of this litigation as it would have been understood in 1973 is as the defendants have proposed it for the following reasons: First, it is the meaning that is most consistent with the claims themselves. The claims themselves refer either to an electrolytic process or to the formation of a porous oxide.

I want to emphasize again that the two claims that refer to a porous oxide refer to the formation of a porous oxide in both the preliminary anodizing tank and the secondary anodizing tank.

Secondly, the meaning proposed by the defendant is most consistent with the specifications contained in the patent, which referred to a porous oxide and which referred to thicknesses sufficient to prevent burning.

I have a hard time imagining anyone reading the specifications along with the claims concluding that anything else could have been intended by this patent.

Third, I find that the prosecution history is most consistent with the defendant's view of the appropriate construction of the term anodizing.

In particular, and as an example without limitation, the abandonment of the 700 patent in view of the German Papst patent, I believe, is clear evidence that there was no intended claim in this patent based upon the formation of merely a barrier oxide in the first anodizing tank.

Finally, the extrinsic and expert testimony is, I would describe, overwhelming in support of the defendant's position that an oxide coating in excess of 1,000 nanometers would have been considered in 1973 a minimum for what any person reasonably skilled in the art would have called anodization.

As we all know, the thicknesses of the oxide coating produced by the phosphoric tank in this litigation were in the neighborhood of 5 nanometers, 200 times smaller than the minimum thickness that would have been considered anodization in 1973.

Those are the reasons for my concluding that the definition of the scope of the asserted claims and the meaning of those claims must include an electrolytic process forming a porous oxide with a thickness of many, many times the native oxide of approximately 5 nanometers.

Now, when I compare the claims as I have construed them, to the process at issue in this litigation, it is obvious that the process does not infringe the Fromson patent.

First of all, the evidence is at best in equipoise as to whether there is any oxide coating formed in the phosphoric cell.

Obviously, if there is no oxide formed in the phosphoric acid cell, there can be no claim of any infringement of the Fromson patent.

The formation of the oxide is rendered doubtful by the evidence of Professor Hobbs' TEM photos which shows a coating, an oxide coating which is thinner after the phosphoric tank than it was when it went into the phosphoric acid tank It goes from a thickness of approximately 7 nanometers to approximately 5 nanometers during that process.

Now, the plaintiff has an explanation for this, and Professor Hobbs had an explanation for this, but the evidence is conflicting and in equipoise, I feel, as to whether there is any real formation of oxide during the phosphoric processing.

This doubt is underlined by the testimony of the defendant's experts to the effect that there is no oxide formation at any voltage under 12 to 13 volts. It is undisputed that the manufacturing processes, which are the object of this infringement litigation, all took place at no more than 8 volts.

So if there was the formation of any oxide coating in the phosphoric acid tank, it did not occur as a result of any electrolytic process.

In fact, the convincing and credible testimony is that the same oxide coating would have occurred in the phosphoric acid tank if there had been no voltage running through that tank.

To summarize then, preliminarily, the Anitec process has not been shown convincingly to produce any oxide coating in the phosphoric acid tank. Or if it does produce an oxide coating, it has not been shown to produce this oxide coating as a result of any electrolytic process, which is an essential requirement of the plaintiff's patent.

In addition, the coating which does emerge from the phosphoric process, either as a result of something that happens in the phosphoric tank or as a result of contact with the water or air after leaving the phosphoric tank, does not result in a coating which could be described as anodized. Several factors support this conclusion.

First, as I noted before, the coating is exceeding thin. Five nanometers is roughly the coating that aluminum acquires spontaneously in the open air. It is the coating that will form almost instantaneously if you scratch a piece of aluminum without doing anything else to it.

The difference between a 1,000 or 2,000 nanometers oxide coating and a 5 nanometer oxide coating is not a difference in degree. It is a difference in kind. Something entirely different is going on.

In addition, whatever coating, or oxide coating emerged from the phosphoric tank, whether as a result of something that occurred in the phosphoric tank or whether it occurred in the air and water after leaving the phosphoric tank, had no effect whatsoever on the question of burning or arcing in the

web. That coating did not assist the web in resolving this problem.

In fact, the defendant's experts clearly showed that the electrical impedance of the aluminum web on leaving the phosphoric tank was less than it was when it went in, so the problem of burning was not assisted; it was exacerbated by the phosphoric tank.

Finally, standard tests used to determine the presence of anodization—the so-called eraser test, the copper-sulfate test, and the bubble test—all confirm that anodization does not occur in the phosphoric tank.

This conclusion supports my earlier finding that the reason that the phosphoric acid tank was not moved by the defendants as a result of the letter from Attorney Dionne was because the process simply did not infringe the Fromson patent.

It is true that the defendants frequently used the word "anodization" to refer to what happened in the phosphoric tank. I considered that a tragedy, in fact, because I think that if the tank had been referred to as a chemical etch tank or a rinse tank or had some other term applied to it, this litigation would never have occurred.

The word "anodization" was used loosely by employees of the defendant to refer to the phosphoric tank simply because the web was rendered anodic in the phosphoric tank and not because there was anything that could be called anodizing as that word is used as a term of art.

Anodizing did not occur in the phosphoric tank, in other words, despite the fact that the word anodizing was used loosely by the employees in connection with the manufacturing process.

Underlining this fact is the admitted fact that oxide formation takes place in the etch tank. Indeed, plaintiff's own expert, Professor Latanision's, stated during his testimony that using the term loosely, you could say that what happens in the etch tank was anodization. Many things could be described as anodization.

And the fact that Professor Latanision's agreed that anodization might occur in the etch tank merely underlines and supports my conclusion that the mere use of the word anodization by the defendants does not suggest or prove or provide evidence of the fact that the anodization occurring, or so characterized, in the phosphoric tank actually was the same as the anodization described in the patent or in any way infringed the patent.

For those reasons, applying the Markman test, I conclude that the meaning and scope of the asserted claims are consistent with those which the defendants have contended are the most appropriate, and that by applying those claims or comparing those claims to the process as construed by me and used by the defendants must lead to the conclusion that there was simply no infringement in this case.

I want to turn now to another issue, which is the question of laches.

The defendants take the position that no later than 1978 the plaintiff had sufficient knowledge to conclude that it had a cause of action against the defendant.

The facts underlying this have already been averted to. These are that counsel for Fromson visited the manufacturing facility in 1978, observed the line, and had an opportunity to interview a principal of the defendant about the manufacturing process on the following day.

All of the processes being used now were in place then, and the defendant argues the plaintiff knew or should have known as of 1978 that he had a cause of action against the defendant, and that it constituted laches to wait for 13 years before bringing this lawsuit.

This factual underpinning has two legal ramifications; one is laches, which I'm talking about now, which would drastically reduce the damage period, and the other is res judicata, which I will be talking about in a moment.

The elements of a claim for laches are described in the federal circuit case of *A.C. Aukerman, Company vs RL Chaides,*

Construction Company, 960 F.2d 1020, which is a 1992 Fed. Circuit case.

The two elements are that the plaintiff delayed filing suit for an unreasonable and inexcusable length of time from the time the plaintiff knew or reasonably should have known of its claim against the defendant; and two, that the delay operated to the prejudice or injury of the defendant.

I have given this issue considerable thought, and I believe that it is a somewhat close question, but it is my determination that the defendant has not made out its defense of laches.

I think it would be unfair or unreasonable to expect a person who is an attorney—albeit an unusually experienced attorney in this particular area—to notice from the production line the configuration of the tanks with sufficient clarity to form the basis for filing a lawsuit.

Having spent three weeks being educated myself through the course of this trial and having had the configuration of the tanks drawn for me more times than I care to remember, and having visited the manufacturing site myself personally, I cannot say that even someone who has been very thoroughly indoctrinated in a short but intense course on this process would be in a position by walking through a manufacturing facility to be able to acquire the sort of specific information that Rule 11, even in its version in 1978, would have required to have in hand for the plaintiff to bring a lawsuit.

Similarly, the deposition of Mr. Rorke the next day, while it did invoke some ambiguous testimony with regard to the manufacturing process, did not enhance or enrich the knowledge that Mr. Lynch would have gained in 1978 to the point where I can say that it was unreasonable and inexcusable for the plaintiff not to bring his lawsuit at that time.

My conclusion with regard to laches is obviously fatal to the res judicata argument. Even if I were to find laches, I would not find that the 1976 Advance litigation is res judicata to this litigation. For one thing, the Advance litigation was filed in 1976, two years before the plant visit. It would have required Mr. Lynch to amend his 1976 complaint to add the additional claim even if he knew of it in 1978.

Finally, I have doubts as to whether this particular litigation could be said to arise from exactly the same nucleus of facts as the Advance litigation, and in any event, I don't believe that the defendant has carried its burden with regard to either of those defenses.

My conclusion, however, is the opposite with regard to the defendant's asserted defense of invalidity based upon the obviousness of the infringement—sorry, the obviousness of the patent at the time that it was applied for.

Again, I have given this issue a great deal of thought, and I recognize that the defendant bears the burden of demonstrating obviousness and subsequent or consequent invalidity by clear and convincing evidence.

I am also very aware that the Court must make sure that it is not using hindsight to determine in 1995 or 1996 what should have been obvious many, many years previous.

But I have to say that I found the testimony of Mr. Barkman extremely convincing on this point, and I believe looking at Chubb, Cook, Barkman, and the other inventions that preceded this one, that the patent itself would have been obvious to an experienced, reasonably experienced person of ordinary skill at the time of the patent application, and for these reasons I find that the patent was invalid as well as not infringed.

Turning to the next point, the question of inequitable conduct. I find that the defendant has not carried its burden of showing inequitable conduct on the part of plaintiff and plaintiff's counsel in the prosecution of the patent application.

While an argument could be made that there was prior art, including the Cook and Barkman material, which perhaps should have been disclosed, I do not believe that the decision not to disclose this demonstrates by anything approaching a clear and convincing standard of any impropriety on the part of the patent applicant.

Beyond this, there is simply no evidence, no substantial evidence beyond mere speculation demonstrating any intent on the part of plaintiff's counsel to perpetuate any type of fraud on the patent office. And I believe that the defense of

inequitable conduct and invalidity of the patent based upon the inequitable conduct has not been proved.

Finally, I want to address the issue of damages. On this question, the plaintiff faces layers of hurdles in proving his damages, and I want to address each one of them.

First, the potential damages in this case have already been substantially limited by my previous decision granting summary judgment for the defendants, Sullivan and Rorke, for failure to mark as required by the applicable federal statute.

Secondly, I find, and I make this finding for purposes of any future proceedings, that even if I am incorrect with regard to my conclusion on infringement and incorrect with regard to my conclusion as to obviousness, and a reviewing court were to find that the patent was valid and infringed, there is simply no convincing evidence of any willfulness on the part of the defendant in infringing the patent, if indeed they are found to have infringed.

In fact, the evidence is quite to the contrary. They responded promptly to Mr. Dionne's instruction that they had violated the patent and reconfigured their production line.

As I said before, I believe this was done in good faith. Even if a court were to disagree with me with regard to my finding of infringement and find that in fact there was infringement in the phosphoric tank, the oxide formation resulting from the phosphoric tank is so minimal that as Professor Hobbs testified it could only be detected with the most advanced scientific procedures. Even in 1995 the equipment and the skill to use these proceedings can only be found in places like MIT. They are not commercially available, let alone in 1978 at the times that are relevant to this litigation.

My conclusion is that the defendants were in good faith with regard to their own decision that nothing occurred in the phosphoric tank that violated Mr. Fromson's patent.

Certainly the plaintiff has not shown by clear and convincing evidence any willfulness on the part of the defendant. So just as there is a limitation on damages based upon the

failure to mark, there is also no enhancement of damages based upon willfulness.

The final layer is that the defendant's theory regarding the calculation of damages is to me manifestly fairer and more reasonable than the theory offered by the plaintiff for the calculation of damages.

My recollection of the testimony is that witnesses who testified on behalf of the defendant confirmed that alternative processes existed that would have produced a product of equal quality without any infringement of Mr. Fromson's patent.

I believe I am entitled—indeed, I believe I am obligated—to take that fact into consideration in determining what appropriate and fair damages would be in this case.

I find that the defendants could, without risking the quality of their product, have altered their production line in 1978 to avoid infringing any patent of the plaintiff's for a cost of approximately $42,500.

If I had found that the defendants had infringed plaintiff's patent, if I had found that plaintiff's patent was valid, I would have imposed damages in the amount of $42,500 plus 50 percent, for a total damage award of $61,750, which I believe would have been consistent with the Georgia-Pacific description of the calculation of damages in this type of litigation. I would also have awarded the plaintiff interest from the date of the filing of the lawsuit.

Obviously, I'm not going to be awarding any damages in the case because I find that the patent was not infringed and I find that the patent was not valid, but if a reviewing court were to find that I am incorrect on either of those conclusions, I would like to make it clear on the record to simplify subsequent proceedings that the damage award I would have made would have been $61,750 plus interest from the date of filing.

Those constitute my findings of fact and conclusions of law with regard to the issues raised in this case. I've gone on for some time. I appreciate your all being here, and if there's nothing else from counsel, I will recess and bid you all good bye for now.

Anything further, Mr. Lynch?

MR. LYNCH: Just one thing. When is this going to be entered, Your Honor?

THE COURT: I'm going to order that the clerk enter judgment in favor of the defendant in accordance with my oral findings and conclusions tomorrow.

MR. LYNCH: Fine.

THE COURT: And you will be receiving a copy of the judgment.

MR. LYNCH: Fine. Thank you.

MR. DUDINE: Your Honor, I certainly don't disagree with the judgment, but two grammatical or maybe typographicals that you might wish to consider in reviewing the transcript, you referred to in the background of the patent to Mr. Fromson obtaining a new replacement patent. You might have meant to say replacement patent, or you might have meant to say re-issued patent, I don't know. And the other one —

THE COURT: (Interposing) I wouldn't—I probably should distinguish between the terms but I wouldn't. That's essentially what I did mean, a re-issued patent.

MR. DUDINE: Fine. The second one was where you were relating to Dr. Moran's electrical impedance test showing that the impedance of the web was less on exiting. I believe you meant to indicate the impedance of the oxide on the web.

THE COURT: What I meant to say, and I'll make this clear, is that the vulnerability of the web to burning following the phosphoric bath was greater and not lesser, and I think that's the essential point.

MR. DUDINE: Thank you, Your Honor, and I'm sure Mr. Lynch and I join in extending our appreciation for your patience and courtesy.

THE COURT: As I told both of you privately, I have enjoyed working with both of you. I've enjoyed getting to know the parties in the case. I'm sorry to have to decide against anyone because the case was so well tried and the facts came across so well. Thank you all very much. Court is in recess.

§ 103 Conditions for patentability; nonobvious subject matter.

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

(b) (1) Notwithstanding subsection (a), and upon timely election by the applicant for patent to proceed under this subsection, a biotechnological process using or resulting in a composition of matter that is novel under section 102 and nonobvious under subsection (a) of this section shall be considered nonobvious if-

(A) claims to the process and the composition of matter are contained in either the same application for patent or in separate applications having the same effective filing date; and

(B) the composition of matter, and the process at the time it was invented, were owned by the same person or subject to an obligation of assignment to the same person.

(2) A patent issued on a process under paragraph (1)-

(A) shall also contain the claims to the composition of matter used in or made by that process, or

(B) shall, if such composition of matter is claimed in another patent, be set to expire on the same date as such other patent, notwithstanding section 154.

(3) For purposes of paragraph (1), the term "biotechnological process" means-

(A) a process of genetically altering or otherwise inducing a single-or multi-celled organism to-

(i) express an exogenous nucleotide sequence,

(ii) inhibit, eliminate augment, or alter expression of an endogenous nucleotide sequence, or

(iii) express a specific physiological characteristic not naturally associated with said organism;

(B) cell fusion procedures yielding a cell line that expresses a specific protein, such as a monoclonal antibody; and

(C) a method of using a product produced by a process defined by subparagraph (A) or (B), or a combination of subparagraphs (A) and (B).

(c) Subject matter developed by another person, which qualifies as prior art only under subsection (f) or (g) of section 102 of this title, shall not preclude patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person.

§112 Specification - 35 U.S.C. § 112

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The specification shall conclude with one or more claims particularly pointing outp and distinctly claiming the subject matter which the applicant regards as his invention.

A claim may be written in independent or, if the nature of the case admits, in dependent or multiple dependent form.

Subject to the following paragraph, a claim in dependent form shall contain a reference to a claim previously set forth and then specify a further limitation of the subject matter claimed. A claim in dependent form shall be construed to incorporate by reference all the limitations of the claim to which it refers.

A claim in multiple dependent form shall contain reference, in the alternative only, to more than one claim previously set forth and then specify a further limitation of the subject matter claimed. A multiple dependent claim shall not serve as a basis for any other multiple dependent claim. A multiple dependent claim shall be construed to incorporate by reference all the limitations of the particular claim in relation to which it is being considered.

An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

96-1286, 96-1287
March 25, 1998, Decided

CYBOR CORPORATION,

Plaintiff-Appellant,

—v.—

FAS TECHNOLOGIES, INC., and FASTAR LTD.,

Defendants-Cross Appellants.

Appealed from: U.S. District Court for the Northern District of California. 93-CV-20712. Judge Whyte.

AFFIRMED.

Tod L. Gamlen, Baker & McKenzie, of Palo Alto, California, argued for plaintiff-appellant. With him on the brief was David I. Roche, of Chicago, Illinois.

Douglas A. Cawley, Hughes & Luce, L.L.P., of Dallas, Texas, argued for defendants-cross appellants. With him on the brief was Aubrey Nick Pittman.

Before MAYER, Chief Judge,[1] RICH, NEWMAN, Circuit Judges, ARCHER, Senior Circuit Judge,[2] MICHEL, PLAGER, LOURIE, CLEVENGER, RADER, SCHALL, BRYSON, and GAJARSA, Circuit Judges. Opinion for the court filed by Senior Circuit Judge ARCHER, in which Circuit Judges RICH, MICHEL, PLAGER, LOURIE, CLEVENGER, SCHALL, BRYSON, and GAJARSA join; Circuit Judge RADER joins as to part IV. Concurring opinions filed by Circuit Judges PLAGER and BRYSON. Opinions concurring in the judgment filed by Chief Judge MAYER, which Circuit Judge NEWMAN joins, and Circuit Judge RADER. Additional views filed by Circuit Judge NEWMAN, which Chief Judge MAYER joins.

ARCHER, Senior Circuit Judge.

Cybor Corporation (Cybor) appeals from the judgment of the United States District Court for the Northern District of California, 93-CV-20712 (Oct. 31, 1995), that Cybor pump, Model 5226, infringes the claims of U.S. Patent No. 5,167,837 (the '837 patent), currently owned by FAStar, Ltd. and exclusively licensed to FAS Technologies, Inc. (collectively FAS). FAS cross-appeals the judgment as to the damages calculation, the denial of enhanced damages, and the refusal to declare the case exceptional and to award attorney fees. A panel heard oral argument on January 29, 1997. Before its opinion issued, however, this court sua sponte on September 5, 1997 ordered that this case be decided in banc.

We affirm the district court's judgment in its entirety. In so doing, we conclude that the Supreme Court's unanimous affirmance in *Markman v. Westview Instruments, Inc., 517 U.S. 370, 116 S. Ct. 1384, 134 L. Ed. 2d 577 (1996)* (Markman II),

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[1] Chief Judge Haldane Robert Mayer assumed the position of Chief Judge on December 25, 1997.

[2] Senior Circuit Judge Glenn L. Archer, Jr. vacated the position of Chief Judge on December 24, 1997.

of our in banc judgment in that case fully supports our conclusion that claim construction, as a purely legal issue, is subject to de novo review on appeal. See *Markman v. Westview Instruments, Inc., 52 F.3d 967, 979, 34 U.S.P.Q.2D (BNA) 1321, 1329 (Fed. Cir. 1995)* (in banc) (Markman I).

BACKGROUND

The '837 patent discloses a device and method for accurately dispensing industrial liquids. The primary use of the patented inventions is to dispense small volumes of liquid onto semiconductor wafers. Claim 1 is representative and reads:[3]

1. In a device for filtering and dispensing fluid in a precisely controlled manner, the combination of:

first pumping means;

second pumping means in fluid communication with said first pumping means; and filtering means between said first and second pumping means, whereby said first pumping means pumps the fluid through said filtering means to said second pumping means;

in which each of said first and second pumping means includes surfaces that contact the fluid, said surfaces being of materials that are non-contaminating to industrial fluids which are viscous and/or high purity and/or sensitive to molecular shear; and comprising means to enable said second pumping means to collect and/or dispense the fluid, or both, at rates or during periods of operation, or both, which are independent of rates or periods of operation, or both, respectively, of said first pumping means.

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[3] The actual patent claim is not written in paragraph form as shown here; we have added the breaks for ease of reference to the claim's limitations.

Figure 2 of the patent illustrates a preferred embodiment of the invention:

[FIGURE FROM ORIGINAL OMITTED]

In the preferred embodiment, the fluid to be filtered enters the system through tubing 14 and travels through the ball valve 24 to the first pumping means 30 via tubing 41. The pumping means 30 then pumps the liquid back through the ball valve 24, which rotates to close tubing 14 and open tubing 102. The liquid then flows to the filter means 100 in which it is filtered. The filtered liquid (filtrate) then flows through tubing 116 and into the second pumping means 120. The filtrate can then be immediately dispensed, accumulated in the upper compartment 131 of the pumping means 120, or simultaneously accumulated and dispensed. The filtrate is dispensed in precise measurements by the second pumping means 120 through tubing 16 at rates and during periods of operation that are independent of the first pumping means 30.

The dual stage pump manufactured by Cybor is used for the same purpose as that of the patented invention—application of liquid in precise, small volumes onto semiconductor wafers. It is illustrated below:

[FIGURE FROM ORIGINAL OMITTED]

In the accused device, pump 1 draws the liquid from a source bottle through a feed line and through a three-way solenoid valve. The solenoid valve then closes the passage to the source bottle and opens the line to the filter, allowing pump 1 to deliver the liquid to the filter. After the liquid passes through the filter, the filtrate flows to a reservoir external to pump 2, where it accumulates until dispensed by pump 2. It is uncontested that the external reservoir, coupled with the second pump, allows the system to accumulate, dispense, or simultaneously accumulate and dispense filtrate. The filtrate leaves the reservoir through another three-way solenoid connector, or valve, and enters the second pump. The

solenoid valve then closes the passage to the reservoir and opens the dispense port, through which the second pump dispenses the filtrate back through the solenoid valve and on through the dispensing port and line.

On September 23, 1993, Cybor sued FAS for a declaratory judgment of non-infringement, invalidity, and unenforceability of the '837 patent. FAS counterclaimed[4] for infringement of all twenty claims and sought damages and injunctive relief. The case proceeded to trial, and the jury found by special verdict that the claims were not invalid, that Cybor literally infringed all the claims except 11, 12, and 16, and that these three remaining claims were infringed under the doctrine of equivalents. The jury determined the infringement to be willful for all claims except claim 16.

After the jury rendered its liability verdict, the district court denied Cybor's renewed motion for Judgment as a Matter of Law (JMOL) that it did not infringe the '837 patent, and also denied FAS's motion for an exceptional case award of attorney fees pursuant to *35 U.S.C. § 285* (1994). Prior to the entry of final judgment, however, this court decided Markman I, which held that claim construction is a matter of law to be determined exclusively by the judge. Cybor then filed a motion for reconsideration of its JMOL motion in light of that decision, but the district court denied reconsideration. After further proceedings on damages, the district court on October 11, 1995, filed its Findings of Fact and Conclusions of Law permanently enjoining Cybor from making, using, or selling its system, awarding FAS $130,912 in damages, and denying FAS's motion for enhanced damages under *35 U.S.C. § 284* (1994). The district court entered its final judgment on October 31, 1995, and these appeals followed.

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[4] Both FAStar and FAS Technologies filed an answer to Cybor's complaint. FAStar alone originally filed the counterclaim, but FAS Technologies was joined as a counterclaimant after the jury trial on liability was completed.

DISCUSSION

I.

A. This court reviews a denial of a motion for JMOL de novo by reapplying the JMOL standard. See *Read Corp. v. Portec, Inc., 970 F.2d 816, 821, 23 U.S.P.Q.2D (BNA) 1426, 1431 (Fed. Cir. 1992).* Under this standard, we can reverse a denial of a motion for JMOL only if the jury's factual findings are not supported by substantial evidence or if the legal conclusions implied from the jury's verdict cannot in law be supported by those findings. See *Kearns v. Chrysler Corp., 32 F.3d 1541, 1547-48, 31 U.S.P.Q.2D (BNA) 1746, 1751 (Fed. Cir. 1994).*

An infringement analysis involves two steps. First, the court determines the scope and meaning of the patent claims asserted, see *Markman II, 116 S. Ct. at 1387,* and then the properly construed claims are compared to the allegedly infringing device, see *Read Corp., 970 F.2d at 821, 23 U.S.P.Q.2D (BNA) at 1431.* Although the law is clear that the judge, and not the jury, is to construe the claims, this case presents the issue of the proper role of this court in reviewing the district court's claim construction.

In Markman I, we held that, because claim construction is purely a matter of law, this court reviews the district court's claim construction de novo on appeal. See *Markman I, 52 F.3d at 979, 981, 34 U.S.P.Q.2D (BNA) at 1329, 1331.* In reaching this conclusion, we recognized that through this process of construing claims by, among other things, using certain extrinsic evidence that the court finds helpful and rejecting other evidence as unhelpful, and resolving disputes en route to pronouncing the meaning of claim language as a matter of law based on the patent documents themselves, the court is not crediting certain evidence over other evidence or making factual evidentiary findings. Rather, the court is looking to the extrinsic evidence to assist in its construction of the written document, a task it is required to perform. The district court's claim construction, enlightened by such extrin-

sic evidence as may be helpful, is still based upon the patent and prosecution history. It is therefore still construction, and is a matter of law subject to de novo review. *Id. at 981, 34 U.S.P.Q.2D (BNA) at 1331* (emphasis in original and footnote omitted).

After the Supreme Court's decision in Markman II, panels of this court have generally followed the review standard of Markman I. See *Serrano v. Telular Corp., 111 F.3d 1578, 42 U.S.P.Q.2D (BNA) 1538 (Fed. Cir. 1997); Alpex Computer Corp. v. Nintendo Co., 102 F.3d 1214, 40 U.S.P.Q.2D (BNA) 1667 (Fed. Cir. 1996); Insituform Techs., Inc. v. CAT Contracting, Inc., 99 F.3d 1098, 40 U.S.P.Q.2D (BNA) 1602 (Fed. Cir. 1996); General Am. Transp. v. Cryo-Trans, Inc., 93 F.3d 766, 39 U.S.P.Q.2D (BNA) 1801 (Fed Cir. 1996).* In some cases, however, a clearly erroneous standard has been applied to findings considered to be factual in nature that are incident to the judge's construction of patent claims. See *Eastman Kodak Co. v. Goodyear Tire & Rubber Co., 114 F.3d 1547, 1555-56, 42 U.S.P.Q.2D (BNA) 1737, 1742 (Fed. Cir. 1997); Serrano, 111 F.3d at 1586, 42 U.S.P.Q.2D (BNA) at 1544,* (Mayer, J., concurring); *Wiener v. NEC Elecs. Inc., 102 F.3d 534, 539, 41 U.S.P.Q.2D (BNA) 1023, 1026 (Fed. Cir. 1996); Metaullics Sys. Co. v. Cooper, 100 F.3d 938, 939, 40 U.S.P.Q.2D (BNA) 1798, 1799 (Fed. Cir. 1996).*[5] We ordered

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[5] It is difficult to reconcile the language and reasoning in this court's recent opinion in *Fromson v. Anitec Printing Plates, Inc., 132 F.3d 1437, 45 U.S.P.Q.2D (BNA) 1269 (Fed. Cir. 1997),* with Markman I, although the opinion purports to do so. As we stated in Markman I, "extraneous evidence [such as the expert testimony in Fromson] is to be used for the court's understanding of the patent" and in doing so, the court "is not crediting certain evidence over other evidence or making factual evidentiary findings." *Markman I, 52 F.3d at 981, 34 U.S.P.Q.2D (BNA) at 1331* (emphasis in original). Rather, we considered such evidence to be an aid to the court in coming to a correct conclusion as to the true meaning of the language employed in the patent. See *id. at 980, 34 U.S.P.Q.2D (BNA) at 1330.* The Supreme Court in effect confirmed this when it stated that the credibility determinations among experts "will be subsumed within the necessarily sophisticated analysis of the whole document." *Markman II, 116 S. Ct. at 1395.* In Fromson, the district court

that this case be decided in banc to resolve this conflict, and we conclude that the de novo standard of review as stated in Markman I remains good law.

B. The Supreme Court framed the question before it in Markman II in the alternative: "whether the interpretation of a so-called patent claim . . . is a matter of law reserved entirely for the court, or subject to a Seventh Amendment guarantee that a jury will determine the meaning of any disputed term of art about which expert testimony is offered." *Markman II, 116 S. Ct. at 1387* (emphasis added). When it answered that question by stating that "we hold that the construction of a patent, including terms of art within its claim, is exclusively within the province of the court," id., the Court held that the totality of claim construction is a legal question to be decided by the judge. Nothing in the Supreme Court's opinion supports the view that the Court endorsed a silent, third option—that claim construction may involve subsidiary or underlying questions of fact.[6] To the contrary, the Court expressly stated that "treating interpretive issues as purely legal will promote (though not guarantee) intrajurisdictional certainty through the application of stare decisis on those questions not yet subject to interjurisdictional uniformity under the authority of the single appeals court." Id. at 1396

"relied primarily on the '754 specification which describes Fromson's first anodization step as producing [a] porous oxide" barrier. *Fromson, 132 F.3d at 1442, 45 U.S.P.Q.2D (BNA) at 1272.* Although the extrinsic evidence - expert testimony, prior art, and scientific tests - confirmed the district court's claim construction, it was directed primarily to whether Anitec's thin, nonporous oxide layer infringed the claims. To this extent, the holding in Fromson affirming the district court's claim interpretation follows Markman I. See *Bell & Howell Document Management v. Altek Sys., 132 F.3d 701, 705-06, 45 U.S.P.Q.2D (BNA) 1033, 1038 (Fed. Cir. 1997); Vitronics Corp. v. Conceptronic, Inc., 90 F.3d 1576, 1584, 39 U.S.P.Q.2D (BNA) 1573, 1578 (Fed. Cir. 1996).*

[6] If this were so, surely the Supreme Court would have discussed whether subsidiary or underlying fact questions should be decided by the judge or the jury.

(emphasis added); see also id. at 1394 (" 'Questions of construction are questions of law for the judge, not questions of fact for the jury" ' (quoting A. Walker, Patent Laws § 75 at 173 (3d ed. 1895))). Indeed, the sentence demonstrates that the Supreme Court endorsed this court's role in providing national uniformity to the construction of a patent claim, a role that would be impeded if we were bound to give deference to a trial judge's asserted factual determinations incident to claim construction.

The opinions in some of our cases suggesting that there should be deference to what are asserted to be factual underpinnings of claim construction assert support from the language in Markman II stating that "construing a term of art after receipt of evidence" is a "mongrel practice," id. at 1390, and that the issue may " 'fall[ ] somewhere between a pristine legal standard and a simple historical fact,' " id. at 1395 (quoting *Miller v. Fenton, 474 U.S. 104, 114, 88 L. Ed. 2d 405, 106 S. Ct. 445 (1985)).* These characterizations, however, are only prefatory comments demonstrating the Supreme Court's recognition that the determination of whether patent claim construction is a question of law or fact is not simple or clear cut; they do not support the view that the Court held that while construction is a legal question for the judge, there may also be underlying fact questions. To the contrary, the court noted that when an issue "falls somewhere between a pristine legal standard and a simple historical fact, the fact/law distinction at times has turned on a determination that, as a matter of sound administration of justice, one judicial actor is better positioned than another to decide the issue in question." Id. (quoting *Miller v. Fenton, 474 U.S. 104, 114, 88 L. Ed. 2d 405, 106 S. Ct. 445 (1985))* (emphasis added). Thus, the Supreme Court was addressing under which category, fact or law, claim construction should fall and not whether it should be classified as having two components, fact and law.

Further supporting the conclusion that claim construction is a pure issue of law is the Supreme Court's analysis of the

role of expert testimony in claim construction. Generally, the Court has recognized the important role played by juries in evaluating the credibility of a witness, a key consideration in determining the appropriate judicial actor to decide an issue. See *Miller, 474 U.S. at 114*. In the context of claim construction, however, the Court reasoned that, while credibility determinations theoretically could play a role in claim construction, the chance of such an occurrence is "doubtful" and that "any credibility determinations will be subsumed within the necessarily sophisticated analysis of the whole document, required by the standard construction rule that a term can be defined only in a way that comports with the instrument as a whole." *Markman II, 116 S. Ct. at 1395;* see also id. at 1394-95 (" 'The testimony of witnesses may be received . . . . But in the actual interpretation of the patent the court proceeds upon its own responsibility, as an arbiter of the law, giving to the patent its true and final character and force.' " (quoting 2 W. Robinson, Law of Patents § 732 at 481-83 (1890))). Such a conclusion is consistent with the view that claim construction, as a form of "document construction," id. at 1395, is solely a question of law subject to de novo review, as noted above. See *Markman I, 52 F.3d at 981, 34 U.S.P.Q.2D (BNA) at 1331*.

Moreover, while the Supreme Court's opinion conclusively and repeatedly states that claim construction is purely legal, another view of the Court's decision also demonstrates that our standard of review remains intact. The Court's primary concern in Markman II was the Seventh Amendment issue of whether a right to a jury trial on claim construction inured to a party due to any potential factual issues involved. Because the Court did not discuss the appellate standard of review, Markman II can be read as addressing solely the respective roles of the judge and jury at the trial level and not the relationship between the district courts and this court. Although our conclusion in Markman I that claim construction is a matter of law was affirmed in all respects, even this narrower

view of Markman II leaves Markman I as the controlling authority regarding our standard of review.

Thus, we conclude that the standard of review in Markman I, as discussed above, was not changed by the Supreme Court's decision in Markman II, and we therefore reaffirm that, as a purely legal question, we review claim construction de novo on appeal including any allegedly fact-based questions relating to claim construction. Accordingly, we today disavow any language in previous opinions of this court that holds, purports to hold, states, or suggests anything to the contrary, see, e.g., *Fromson, 132 F.3d at 1444, 45 U.S.P.Q.2D (BNA) at 1274* ("The district court's findings of scientific/technological fact were material to the issue of construction of the term 'anodizing.' "); *Eastman Kodak, 114 F.3d at 1555-56, 42 U.S.P.Q.2D (BNA) at 1742* (affirming district court's claim construction "recognizing both the trial court's 'trained ability to evaluate [expert] testimony in relation to the overall structure of the patent' and the trial court's 'better position to ascertain whether an expert's proposed definition fully comports with the specification and claims . . . .' (quoting *Markman II, 116 S. Ct. at 1395)); Wiener, 102 F.3d at 539, 41 U.S.P.Q.2D (BNA) at 1026* (citing Markman II as controlling our standard of review and parenthetically quoting language from Markman II that claim construction " 'falls somewhere between a pristine legal standard and a simple historical fact.' "); *Metaullics, 100 F.3d at 939, 40 U.S.P.Q.2D (BNA) at 1799* ("Because claim construction is a mixed question of law and fact, we may be required to defer to a trial court's factual findings. Where a district court makes findings of fact as part of claim construction, we may not set them aside absent clear error." (citations omitted)).

II.

Cybor argues in this appeal that the district court improperly construed the two means-plus-function limitations in the relevant claims of the '837 patent—the "second pumping

means" and the "means to enable" the second pumping means to accumulate liquid, dispense liquid, or both. Cybor also challenges the district court's construction of the limitation requiring that the fluid flow "to a second pumping means." All of these arguments turn on the question of whether the district court erred in refusing to limit the scope of the claims based on statements made to the examiner during prosecution.[7] In particular, Cybor contends that the prosecution history does not allow the claimed "second pumping means" to cover any reservoir for accumulating fluid that is external to the second pump. Because Cybor's reservoir is external, Cybor argues that its second pump does not meet the second pumping means limitation. Its second pump alone, without regard to the external reservoir, is not able to satisfy the functional limitation of enabling the second pumping means to "accumulate liquid, dispense liquid, or both." With an intervening external reservoir, Cybor also argues that the fluid does not flow "to" a second pumping means from the filter means as required by the claims.

A. Under § 112, P 6, an accused device with structure not identical to the structure described in the patent will literally infringe the patent if the device performs the identical function required by the claim with a structure equivalent to that described in the patent. See *Micro Chem., Inc. v. Great Plains Chem. Co., 103 F.3d 1538, 1547, 41 U.S.P.Q.2D (BNA) 1238, 1245-46 (Fed. Cir. 1997)*. Prosecution history is relevant to

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[7] Because Cybor's claim construction arguments relate to the narrowing of claim scope required by prosecution history, we need not consider whether equivalence under § 112, P 6 is a question of law or fact. See *Markman I, 52 F.3d at 977 n.8, 34 U.S.P.Q.2D (BNA) at 1327 n.8.* Here, the question of equivalence was given to the jury and Cybor does not challenge the equivalence of its accused device if prosecution history does not narrow the scope of the claims as Cybor argues. One concurring opinion also recognizes that Cybor's claim construction arguments relate solely to whether the prosecution history requires the exclusion of the external "reservoir structures like Cybor's from consideration as an equivalent under § 112(6)." See Opinion Concurring in the Judgment of Chief Judge Mayer, infra, at 13-14.

the construction of a claim written in means-plus-function form. See *United States v. Telectronics, Inc., 857 F.2d 778, 782, 8 U.S.P.Q.2D (BNA) 1217, 1220 (Fed. Cir. 1988); Rite-Hite Corp. v. Kelley Co., 819 F.2d 1120, 1123, 2 U.S.P.Q.2D (BNA) 1915, 1917 (Fed. Cir. 1987).* Indeed, "just as prosecution history estoppel may act to estop an equivalence argument under the doctrine of equivalents, positions taken before the PTO may bar an inconsistent position on claim construction under § 112, P 6." *Alpex, 102 F.3d at 1221, 40 U.S.P.Q.2D (BNA) at 1673.* Clear assertions made in support of patentability thus may affect the range of equivalents under § 112, P6. *Cf. American Permahedge, Inc. v. Barcana, Inc., 105 F.3d 1441, 1446, 41 U.S.P.Q.2D (BNA) 1614, 1618 (Fed. Cir. 1997);* Athletic Alternatives, *Inc. v. Prince Mfg., Inc., 73 F.3d 1573, 1582, 37 U.S.P.Q.2D (BNA) 1365, 1373 (Fed. Cir. 1996).* The relevant inquiry is whether a competitor would reasonably believe that the applicant had surrendered the relevant subject matter. See *Insituform Techs., Inc., v. CAT Contracting, Inc., 99 F.3d 1098, 1107-08, 40 U.S.P.Q.2D (BNA) 1602, 1608 (Fed. Cir. 1996).*

Cybor relies on two responses by the inventors to the examiner's obviousness rejection of the claims for its position that a pump structure with any external reservoir was given up during prosecution. In each instance, the examiner had cited Storkebaum et al., U.S. Patent No. 4,749,476 (Storkebaum). Storkebaum's container not only collects permeate; it also vents or discharges the fluid. The container feeds a conveying pump that powers the flow of a big circulation loop. The design of Storkebaum is not for the controlled dispensing of fluid. In the first response, the inventors argued that "Storkebaum specifically provides a separate container 12 for collecting permeate. Obviously, Storkebaum does not teach the collection of fluid in a second pumping means." (Emphasis added). In response to a later rejection, the inventors argued that "Storkebaum discloses a permeate collecting container 12 that is separate from the conveying pump 13. Nothing in Storkebaum discloses or makes obvious the claimed inven-

tion, nor the precise or flexible control provided by the second pump means of Claim 1." (Emphasis in original). From these statements, Cybor contends that FAS is precluded from asserting that a pump device with an external reservoir is a structural equivalent under § 112, P 6 to its patented device and that the district court, as a matter of law, should not have permitted the jury to consider its external reservoir in determining whether the differences between Cybor's second pump and the '837 patent's second pumping means were insubstantial. FAS responds that the district court made all of the required determinations regarding claim construction and, in doing so, fully considered the prosecution history at issue. It then submitted the construed claims to the jury for its determination of infringement.[8]

We are not convinced that the district court erred in its claim construction or in denying Cybor's motion for JMOL. The district court construed several limitations, or disputed language, in the claims. With respect to the second pumping means limitation, the jury was instructed that it "refers to a structure identical to the structure disclosed in the specification of the patent, or the equivalent to that structure, which performs the function of fluid accumulator/dispense pump." With this instruction, the district court did not narrow the scope of the claim language to exclude a pump with any external reservoir as urged by Cybor. Instead, the jury was instructed to determine whether Cybor's device, with its pump and attached reservoir, was structurally equivalent and whether it had the same functionality as the second pumping means of the '837 patent.[9]

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[8] Cybor contends that the jury was not adequately instructed on the meaning of the claims. We note, however, that this case was tried before Markman I and that, while a fuller instruction to the jury on the meaning of the claim might be desirable, the instructions were not erroneous. Moreover, the district court's denial of the motion for reconsideration approved the additional, presumptive construction of the claims by the jury.

[9] One concurring opinion suggests that this court cannot affirm the decision below under a de novo standard of review, asserting that the

From our reading of the patent document and the prosecution history, we agree with the district court's construction and jury instructions. While it is quite clear the inventors limited the scope of their claims to overcome the Storkebaum reference, they emphasized the separateness of Storkebaum's container, both physically and functionally, as compared to the claimed invention. For example, the statements noted that Storkebaum "provides a separate container" and that it has a container "that is separate from the conveying pump." The specification of the '837 patent elaborates on the structure of the second pumping means and its "means to enable" as having tubing connecting the second pumping means to the second incremental pump advancement means, see col. 5, lines 49-52. While in the preferred embodiment, the '837 patent disclosed a storage reservoir inside the pump, it is not disputed that the claimed second pumping means encompasses both a pump and a reservoir having connecting tubing.

The Storkebaum device differs materially from the patented invention. Storkebaum discloses a filtering system to separate pressure sensitive substances from a liquid suspension. It has a conveying pump that operates to circulate the fluid through a large closed circuit loop. It also has a separate reservoir to collect and regulate the amount of permeate in the closed circuit. Thus, the container in the Storkebaum apparatus has the separate function and capability of venting or discharging excessive liquid in order to prevent undesirable build up of liquids in the system.

In view of the significant differences between the cited Storkebaum patent and the claimed invention, including the structurally separate container and independent function of discharging excess fluid in Storkebaum, the prosecution state-

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basis for the jury's decision is unclear. We disagree that the jury could have had in mind the several variations posited by the concurrence. It is patently impossible for Cybor's pump, without a reservoir, to perform the functions called for by the patent. Thus, the jury had to consider the combination of Cybor's pump and the external, attached reservoir as being a "pumping means" equivalent to the structure disclosed in the patent, which consisted of a pump with an internal reservoir.

ments cannot properly be interpreted as precluding coverage of every type of external reservoir. In particular, we agree with the district court's apparent conclusion that these statements only disclaimed a physically unattached reservoir which has independent functionality. They did not disclaim a reservoir which is physically connected to the pump and which only collects fluid to be dispensed by that pump. Thus, we conclude that the district court did not err in instructing the jury in a manner which would permit it to consider the equivalency of Cybor's pump and reservoir to the claimed second pumping means. Further, it did not err in denying Cybor's JMOL motion on this issue.

B. Cybor further challenges the district court's claim interpretation regarding the claim limitation that the first pumping means pumps the fluid through the filtering means "to" the second pumping means. Cybor contends that this language requires that the liquid flow directly from the filtering means to the second pumping means without passing through any additional components. Because the fluid in Cybor's device flows through the external reservoir, which Cybor views as a component separate from the claimed second pumping means, Cybor argues that it does not infringe.

We reject Cybor's arguments because, as previously discussed, the external reservoir in the Cybor's device was apparently held by the jury to be a part of its "second pumping means" and not a separate component.

We also agree with the district court's interpretation that the "to" limitation requires only that the liquid move from the filter "in a pathway with a destination of the second pumping means" and does not preclude the fluid from passing through intervening components. Cf. Webster's II New Riverside Univ. Dictionary 1214 (1984) (defining "to" as "in a direction toward"); see *Vitronics, 90 F.3d 1576 at 1584 n.6, 39 U.S.P.Q.2D (BNA) at 1578 n.3* (noting that, although technically extrinsic evidence, the court is free to consult dictionaries at any time to help determine the meaning of claim

terms). Nothing in the specification or prosecution history suggests the interpretation put forth by Cybor.

Applying the above interpretations, substantial evidence supports the jury's verdict that Cybor's device literally infringes the claims of the '837 patent. Accordingly, we conclude that the district court properly denied Cybor's motion for JMOL as to literal infringement.

III.

Cybor also challenges the denial of its JMOL motion on the ground that its device does not infringe the '837 patent under the doctrine of equivalents. The jury determined that claims 11, 12, and 16 are not literally infringed but are infringed under the doctrine of equivalents. Claims 10, 11, and 12 read:

> 10. A method for filtering and dispensing industrial fluids which are viscous and/or high purity and/or shear sensitive, comprising the steps of: pumping the fluid through filtering means by first pumping means to second pumping means; accumulating the fluid in second pumping means at rates or during periods of operation, or both, independent of the rates or periods of operation, or both, respectively, of said first pumping means; and dispensing the fluid by operating said second pumping means.
>
> 11. The method of claim 10 wherein said accumulating step is achieved by operating said second pumping means on an intake stroke at the same rate at which said first pumping means is pumping said fluid through said filter, so that the fluid which has been filtered is accumulated in said second pumping means without being dispensed from said second pumping means.
>
> 12. The method of claim 10 wherein said accumulating step includes operating said second pumping means to draw said filtered fluid at a rate slightly greater than

> the rate at which said filtered fluid is being pumped by said first pumping means, such that there is a slight drawback of said fluid from a dispensing means of said second pumping means.

(Emphasis added). Claim 16 is a combination claim that reads:

> 16. In a device for filtering and dispensing high-purity and/or viscous and/or shear-sensitive fluid, the combination of: a first diaphragm-type pump; filtering means connected to receive the fluid from said first diaphragm-type pump; and a second diaphragm-type pump connected to receive the fluid from said filtering means, in which each of said first and second diaphragm-type pumps includes surfaces that contact the fluid, said surfaces being of materials that are non-contaminating to industrial fluids which are viscous and/or high purity and/or sensitive to molecular shear; and comprising means to enable said second diaphragm-type pump to collect and/or dispense the fluid, or both, at rates or during periods of operation, or both, which are independent of rates or periods of operation, or both, respectively of said first diaphragm-type pump.

(Emphasis added).

An accused device that does not literally infringe a claim may still infringe under the doctrine of equivalents if each limitation of the claim is met in the accused device either literally or equivalently. See *Warner-Jenkinson Co. v. Hilton Davis Chem. Co., 137 L. Ed. 2d 146, 117 S. Ct. 1040, 1054 (1997)*; see also *Pennwalt Corp. v. Durand-Wayland, Inc., 833 F.2d 931, 935, 4 U.S.P.Q.2D (BNA) 1737, 1740 (Fed. Cir. 1987)* (in banc). Prosecution history estoppel provides a legal limitation on the application of the doctrine of equivalents by excluding from the range of equivalents subject matter surrendered during prosecution of the application for the patent. See *Warner-Jenkinson, 117 S. Ct. at 1049*. The estoppel may arise from matter surrendered as a result of amendments to

overcome patentability rejections, see id., or as a result of argument to secure allowance of a claim, see *Wang Lab., Inc. v. Mitsubishi Elecs., Inc., 103 F.3d 1571, 1578, 41 U.S.P.Q.2D (BNA) 1263, 1269 (Fed. Cir. 1997)*. Prosecution history estoppel is a legal question subject to de novo review on appeal. See *Insituform, 99 F.3d at 1107, 40 U.S.P.Q.2D (BNA) at 1609*.

Cybor argues that there is no infringement under the doctrine of equivalents because prosecution history estoppel precludes FAS both from claiming an external reservoir and a pump as an equivalent to the second pumping means of claims 11 and 12 and from claiming an external, attached reservoir as the equivalent to the means to enable the second diaphragm-type pump in claim 16 to accumulate, dispense, or both accumulate and dispense the liquid. Additionally, Cybor urges that, because the accused device has an intervening reservoir, the limitation requiring the filtrate to flow to the second pumping means in claims 11 and 12 would not equivalently be met.

These arguments are unpersuasive for the same reasons that we rejected them under our § 112, P 6 claim construction and literal infringement analysis. The inventor's statements to the PTO regarding the Storkebaum reference, given the marked differences between the reference and the patented and accused devices, do not show the deliberate, unequivocal surrender of all external reservoirs. See *Read Corp. v. Portec, Inc., 970 F.2d 816, 824, 23 U.S.P.Q.2D (BNA) 1426, 1433 (Fed. Cir. 1992)* ("Every statement made by a patentee during a prosecution to distinguish a prior art reference does not create a separate estoppel. Arguments must be viewed in context."). Because Cybor's pump and reservoir with connecting tubing do not fall within the range of subject matter relinquished, prosecution history does not preclude infringement under the doctrine of equivalents. Accordingly, the district court's denial of Cybor's motion for JMOL with respect to infringement under the doctrine of equivalents was not error.

IV.

On cross-appeal, FAS argues that, in light of the jury's determination that Cybor's infringement was willful, the district court erred both by refusing to find this case exceptional, and thus denying attorney fees under *35 U.S.C. § 285* (1994), and by denying enhanced damages under *35 U.S.C. § 284* (1994). FAS also challenges the district court's approach in calculating damages.

A. The determination of whether a case is exceptional and, thus, eligible for an award of attorney fees under § 285 is a two-step process. See *Reactive Metals Alloys Corp. v. ESM, Inc., 769 F.2d 1578, 1582, 226 U.S.P.Q. (BNA) 821, 824 (Fed. Cir. 1985)*. First, the district court must determine whether a case is exceptional, a factual determination reviewed for clear error. See *Baldwin Hardware Corp. v. Franksu Enter. Corp., 78 F.3d 550, 563, 37 U.S.P.Q.2D (BNA) 1829, 1838 (Fed. Cir. 1996)*. After determining that a case is exceptional, the district court must determine whether attorney fees are appropriate, a determination that we review for an abuse of discretion. See *Molins PLC v. Textron, Inc., 48 F.3d 1172, 1186, 33 U.S.P.Q.2D (BNA) 1823, 1833 (Fed. Cir. 1995)*. A district court abuses its discretion when its decision is based on clearly erroneous findings of fact, is based on erroneous interpretations of the law, or is clearly unreasonable, arbitrary or fanciful. See *Fraige v. American-National Watermattress Corp., 996 F.2d 295, 297, 27 U.S.P.Q.2D (BNA) 1149, 1151 (Fed. Cir. 1993)*.

We conclude that the district court's denial of exceptional status was not clearly erroneous. The court specifically noted that it considered the evidence of willful infringement sufficient but weak. Similarly, it considered the evidence of copying also to be weak. The court concluded that Cybor's arguments in litigation, while ultimately unsuccessful, were not frivolous or asserted for an improper purpose and that Cybor litigated in good faith. Finally, the court concluded that

evidence supported Cybor's contention that it in good faith did not consider its system to be infringing.

Contrary to FAS's assertions, a finding of willful infringement does not require a finding that a case is exceptional. See *Modine Mfg. Co. v. The Allen Group, Inc., 917 F.2d 538, 543, 16 U.S.P.Q.2D (BNA) 1622, 1624 (Fed. Cir. 1990).* Moreover, FAS's mere argument that Cybor's defenses and claims were "baseless" and pursued in "bad faith" does not undermine the district court's conclusions to the contrary. The record evidence supports the district court's conclusion that Cybor acted in good faith. Moreover, Cybor's arguments, particularly relating to claim construction and prosecution history estoppel, were not meritless, and resolution of those issues in FAS's favor was far from a foregone conclusion.

B. FAS further challenges the district court's decision not to enhance the damages in this case. The statute allows a court to enhance damages "up to three times the amount found or assessed." *35 U.S.C. § 284* (1994). A denial of enhanced damages under § 284 is reviewed on appeal for an abuse of discretion. See *Electro Medical Sys., S.A. v. Cooper Life Sciences, Inc., 34 F.3d 1048, 1056, 32 U.S.P.Q.2D (BNA) 1017, 1023 (Fed. Cir. 1994).* Enhanced damages have been awarded when a party is found to have willfully infringed or to have acted in bad faith. Id. A finding of willfulness, however, does not mandate enhanced damages. See *Read Corp., 970 F.2d at 826, 23 U.S.P.Q.2D (BNA) at 1435.* Instead, "the paramount determination . . . is the egregiousness of the defendant's conduct based on all the facts and circumstances." Id.

We conclude that the district court did not abuse its discretion in denying enhanced damages. Particularly, we note that there is no merit to the argument that a finding of willfulness but a denial of enhanced damages is necessarily an abuse of discretion. See *Modine, 917 F.2d at 543, 16 U.S.P.Q.2D (BNA) at 1624.* Indeed, the district court determined that the evidence regarding willfulness and copying was weak. Moreover, although Cybor was found to infringe

all twenty of the claims, this result does not mean that the case was not close, particularly in light of its justifiable albeit unsuccessful arguments regarding the prosecution history of the '837 patent. Finally, nothing in the record supports FAS's arguments that Cybor litigated in an inappropriate fashion; the district court actually found the contrary to be true. Thus, we conclude that the district court did not abuse its discretion in denying enhanced damages.

C. Finally, FAS contests both the district court's method in calculating damages and the court's ultimate damages award. Section 284 requires that the damages awarded to a claimant must be adequate to compensate for infringement. See *Rite-Hite Corp. v. Kelley Co., 56 F.3d 1538, 1544, 35 U.S.P.Q.2D (BNA) 1065, 1068 (Fed. Cir. 1995)* (in banc). The amount of damages determined by a district court is a question of fact that is reviewed for clear error on appeal, while the method used by a district court in reaching that determination is reviewed for an abuse of discretion. See *Stryker Corp. v. Intermedics Orthopedics, Inc., 96 F.3d 1409, 1413, 40 U.S.P.Q.2D (BNA) 1065, 1068 (Fed. Cir. 1996).*

FAS argues that the district court abused its discretion by using a method that was "too stringent" and thus did not afford adequate relief. We disagree. The district court performed a thorough, well-reasoned analysis of the facts underlying the award of damages. Contrary to FAS's assertions, the court acted within its discretion in its evaluation of the two-supplier market by concluding that FAS's sale to the purchaser would not have occurred at the same time that the infringing sales occurred because of FAS's prior history with that purchaser. As to the other aspects of the methodology challenged by FAS, we conclude that the district court weighed the evidence before it in an appropriate fashion. We decline FAS's inappropriate invitation that we essentially reweigh the record evidence.

CONCLUSION

Because the district court properly denied defendant's motion for JMOL, did not abuse its discretion in its damages methodology or in its decision not to enhance damages, and did not clearly err in determining that this case was not exceptional or clearly err in determining the amount of damages, we affirm.

AFFIRMED

PLAGER, Circuit Judge, concurring.

The concerned reader of the several opinions in this case might be led to believe that there is more to this case than there is. This otherwise unremarkable case was taken in banc for the sole purpose of laying to rest any residual doubts about how, in claim construction, the verbalizations surrounding the familiar "fact-law" dichotomy should be understood. I join the court's opinion and judgment, eliminating the unnecessary obfuscation that seems to have emerged since our decision in *Markman v. Westview Instruments, Inc., 52 F.3d 967, 34 U.S.P.Q.2D (BNA) 1321 (Fed. Cir. 1995)* (in banc) (hereinafter Markman I).

In Markman I we held that "claim construction is a matter of law," and that "the construction given the claims is reviewed de novo on appeal." *Id. at 979.* The Supreme Court agreed with our view, and concluded that the Seventh Amendment right to trial by jury was not an obstacle. *Markman v. Westview Instruments, Inc., 517 U.S. 370, 134 L. Ed. 2d 577, 116 S. Ct. 1384, 1391-93 (1996)* (Markman II).

At the trial stage of a patent infringement suit, this means that the trial judge is obligated to determine the meaning of the claims, and, if a jury is used for the infringement phase, to instruct the jury accordingly. In the course of seeking to understand the nature and scope of the invention set forth in

the claims, it is standard doctrine that the judge focuses on the language of the claims, as explained by the patent's written description, and as constrained by the course of the patent's prosecution. If need be, the trial judge may seek understanding outside the patent proper, from relevant texts and materials, and from experts in the art. None of this involves "fact-finding" in the sense of the traditional fact-law dichotomy. See, for example, the Supreme Court's effort to decide whether a tomato was a "fruit" or a "vegetable." Regarding the meaning of those words, the Court said: "Of that meaning the court is bound to take judicial notice, as it does in regard to all words in our own tongue; and upon such a question dictionaries are admitted, not as evidence, but only as aids to the memory and understanding of the court." *Nix v. Hedden, 149 U.S. 304, 306-07, 37 L. Ed. 745, 13 S. Ct. 881 (1893).*

The effort is to understand the meaning of the terms in the claims. To the extent that involves delving into factual matters, such materials simply become part of the process of understanding. It hardly seems necessary to state that the point of seeking understanding of the terms in which the claims are cast is not for the sake of understanding in the abstract, but to ensure as much as the intrinsic nature of language permits that the court's interpretation is a correct one.

On appeal, this court has the benefit of the trial judge's considered view, and the record of the effort made at trial to assist the judge in understanding the terms of the claim. Though we review that record "de novo," meaning without applying a formally deferential standard of review, common sense dictates that the trial judge's view will carry weight. That weight may vary depending on the care, as shown in the record, with which that view was developed, and the information on which it is based.

It may or may not be true that the trial judge will have had virtually unlimited time and opportunity to pursue the matter. In any event, just where the comparative advantage in claim

construction effort and accuracy lies in any particular case will be observable on appeal, and will no doubt influence the weight given to the trial court's view. And just as three minds are deemed better than one in deciding appeals, four minds may often be better than three when a complex claim construction is at issue.

This court's decision in Markman I, reaffirmed today, simply means that we do not spend our and appellate counsels' time debating whether the trial court's information base constitutes findings of "fact" or conclusions of "law," with verbally different standards of review. Instead both they and we can focus on the question that the trial court addressed, the question that counts: what do the claims mean? As we all recognize, that is not always easy to know, and much turns on the answer.

The decision today should help institute a simplified and clarified method by which both trial and appellate courts address claim construction issues, pursuant to the rules established in this court's Markman I opinion. Our purpose is to improve the process of patent infringement litigation for the benefit of patentees and their competitors, and ultimately the public. Whether this approach to patent litigation will in the long run prove beneficial remains to be seen. There is every reason to believe it will, and certainly to believe it is better than what we had. But it may be some time before we have enough experience with "Markman hearings" and with appellate review under the new regime to draw any empirically sound conclusions. In such circumstances there is much to be said for refraining from premature and argumentative judgments about what it all means, and for allowing sufficient time to actually see how it works.

BRYSON, Circuit Judge, concurring.

While I join the opinion of the court without reservation, I think it important to note that our adoption of the rule that claim construction is an issue of law does not mean that we intend to disregard the work done by district courts in claim construction or that we will give no weight to a district court's conclusion as to claim construction, no matter how the court may have reached that conclusion. Simply because a particular issue is denominated a question of law does not mean that the reviewing court will attach no weight to the conclusion reached by the tribunal it reviews. In fact, reviewing courts often acknowledge that as to particular legal issues lower tribunals have special competence and their judgments on those legal issues should be accorded significant weight. For example, the Supreme Court typically defers to the construction of a state statute adopted by the regional court of appeals that includes that state. See *Propper v. Clark, 337 U.S. 472, 486-87, 93 L. Ed. 1480, 69 S. Ct. 1333 (1949).* Similarly, this court has routinely noted that although contract interpretation is a question of law, the interpretation of a contract by a Board of Contract Appeals, in light of the Board's expertise in such matters, "is afforded careful consideration and great respect." *Alvin, Ltd. v. United States Postal Serv., 816 F.2d 1562 (Fed. Cir. 1987).* Indeed, the Supreme Court has made much the same point in referring to its review of this court's decisions on patent law, noting that the Court would "leave such refinement [of the legal test for applying the doctrine of equivalents] to [the Federal Circuit's] sound judgment in this area of its special expertise." *Warner-Jenkinson Co. v. Hilton Davis Chem. Co., 137 L. Ed. 2d 146, 117 S. Ct. 1040, 1054 (1997).*

The Supreme Court in Markman stated that it would be a rare case in which claim construction would turn on an issue such as a credibility judgment between two competing expert witnesses. See *116 S. Ct. at 1395.* Such cases, however, may arise, and in those cases it would be entirely appropriate—and consistent with our characterization of claim construction as

a question of law—to factor into our legal analysis the district court's superior access to one of the pertinent tools of construction.

That does not mean that we defer to a district court on legal matters unless we find that the court has committed clear error with respect to an issue that should be characterized as factual. What it means is that we approach the legal issue of claim construction recognizing that with respect to certain aspects of the task, the district court may be better situated than we are, and that as to those aspects we should be cautious about substituting our judgment for that of the district court.

MAYER, Chief Judge, with whom NEWMAN, Circuit Judge, joins, concurring in the judgment.

I am compelled to concur in the judgment of the court, but I respectfully disagree with the opinion because it profoundly misapprehends *Markman v. Westview Instruments, Inc., 517 U.S. 370, 116 S. Ct. 1384, 134 L. Ed. 2d 577 (1996).* The Supreme Court concluded there that the historical record is insufficiently firm to declare that juries construed patent claims in England when the Seventh Amendment to the Constitution was adopted in 1791. So it decided as a matter of policy that judges, not juries, are better able to perform this task given the complexity of evidence and documentation. This was a perilous decision of last resort. For juries regularly render verdicts in civil cases based on complex forensic and documentary evidence of equal or greater difficulty than seen in patent cases. And the implications for criminal cases under Article III and the Sixth Amendment are even more profound. Increasingly complex cases involving scientific and complicated documentary evidence are presented to criminal juries which, of course, decide matters of life and liberty, not merely money. Nevertheless, having so ruled, it seems to me

the Court would not also have repealed part of the Federal Rules of Civil Procedure and Evidence without so much as a mention that district courts no longer have discretion to admit expert evidence, see *Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579, 125 L. Ed. 2d 469, 113 S. Ct. 2786 (1993)*, and need not find facts when evidence is disputed in these cases. Nor would it have so excused this court from the normal, historical role of appellate courts to review for reversible error, and installed it as a collegial trial court.

I. STANDARD OF REVIEW

We review the denial of a motion for judgment as a matter of law de novo by reapplying the same standard. See *Read Corp. v. Portec, Inc., 970 F.2d 816, 821, 23 U.S.P.Q.2D (BNA) 1426, 1431 (Fed. Cir. 1992)*. Under this standard, appellant must show that "the jury's factual findings, presumed or express, are not supported by substantial evidence or, if they are, that the legal conclusions implied from the jury's verdict cannot in law be supported by those findings." *Alpex Computer Corp. v. Nintendo Co., 102 F.3d 1214, 1221, 40 U.S.P.Q.2D (BNA) 1667, 1672 (Fed. Cir. 1996)* (quoting *Kearns v. Chrysler Corp., 32 F.3d 1541, 1547-48, 31 U.S.P.Q.2D (BNA) 1746, 1751 (Fed. Cir. 1994)*).

Our review of claim construction is controlled by the Supreme Court's judgment in *Markman, 517 U.S. 370, 116 S. Ct. 1384, 134 L. Ed. 2d 577*, not the opinion of this court it reviewed, *52 F.3d 967, 34 U.S.P.Q.2D (BNA) 1321 (Fed. Cir. 1995)*; the Supreme Court did not adopt this court's reasoning as its own. Though it could have done so easily, the Court chose not to accept our formulation of claim construction: as a pure question of law to be decided de novo in all cases on appeal.[10] If it had, there would have been no need for its

[10] Rather than bluntly force the square peg of claim construction into the round hole of fact or law, the Court described the questions presented by claim construction in more chary terms: "but the sounder course, when available, is to classify a mongrel practice," "no clear answers," "in theory there could be a case," "leaves us doubtful," "in the

extensive exegesis about the Seventh Amendment and whether juries must construe claims that have evidentiary underpinnings or whether the importance of uniformity is best served by giving these evidentiary questions of meaning to a judge. It would have been a simple matter for the Court to give short shrift to this argument by proclaiming construction purely, solely, and always a matter of law that would never have gone to the jury.

The Supreme Court recognized that in some cases there will be conflicting evidence that has to be resolved—where there are factual determinations that are more than just incident to claim construction—such as the understanding of one skilled in the art at the time the patent application was filed. In these cases, all that Markman stands for is that the judge will do the resolving, not the jury. Wisely, the Supreme Court stopped short of authorizing us to find facts de novo when evidentiary disputes exist as part of the construction of a patent claim and the district court has made these findings without committing clear error. See *Fromson v. Anitec Printing Plates, Inc., 132 F.3d 1437, 1446, 45 U.S.P.Q.2D (BNA) 1269, 1275 (Fed. Cir. 1998)* (findings of fact made by a district court to resolve disputes as to the meaning of claim terms are affirmed absent clear error); *Eastman Kodak Co. v. Goodyear Tire & Rubber Co., 114 F.3d 1547, 1555-56, 42 U.S.P.Q.2D (BNA) 1737, 1742 (Fed. Cir. 1997)* (reliance on expert testimony to clarify ambiguous claim term is acceptable and deference is given to the trial court's credibility determination). Rather, when the judge finds facts or accepts the factual determinations of a jury, those facts are entitled to greater deference than de novo fact finding on appeal.

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main," "we accordingly think there is sufficient reason to treat construction of terms of art like many other responsibilities that we ceded to a judge," "independent reason to allocate," "treating interpretive issues as purely legal will promote . . . ." *Markman, 517 U.S. 370, 116 S. Ct. 1384 at 1390, 134 L. Ed. 2d 577* (emphasis added). Even a cursory reading of that opinion indicates that the Court meant to determine who should interpret the claims, without mandating a standard of appellate review to be used under all circumstances.

In Fromson, the trial judge admitted expert testimony to develop the record on the meaning of the word "anodized," as it was understood by one skilled in the art at the time of the invention. *Fromson, 132 F.3d at 1444-45, 45 U.S.P.Q.2D (BNA) at 1273-74.* Based on that extrinsic evidence, he found "in 1973 no reasonable practitioner of this process would have had the opinion that a non-porous non-adherent oxide coating, as thin as the native 5 nanometer coating found naturally in the environment, of phosphoric oxide, constituted an anodized surface." *Id. at 1444, 45 U.S.P.Q.2D (BNA) at 1274.* This finding limited the meaning of the word anodized beyond what a standard definition required: "To subject [a metal] to action by making [it] the anode of a cell before coating with a protective or decorative film." *Id., 45 U.S.P.Q.2D (BNA) at 1273* (quoting Webster's Third Int'l Dictionary). This finding also conflicted with the alleged infringer's description of its own oxide coating process as anodization. Nevertheless, the district court construed the word anodized to mean: "an electrolytically formed, adherent, porous aluminum oxide coating sufficiently thick (meaning thicker than native oxide) . . . ." *Id. at 1445, 45 U.S.P.Q.2D (BNA) at 1274.* Because the accused process did not form an oxide coating thicker than native oxide, the district court entered a judgment of noninfringement.

Even had we disagreed with the construction given by the trial court in Fromson, we were not tasked by our standard of review to reexamine de novo each of the days of testimony and volumes of record relating to interpretation of the word anodized. This court did not affirm the trial court's judgment because it had educed the best construction of the word anodized. It did so because the district court's construction was properly predicated on a factual finding about what anodized meant to one skilled in the art in 1973, which on the appellate record presented by the parties was not clearly erroneous. The Supreme Court never contemplated in Markman that we feign first-hand experience with the technology, or that we embellish our abilities by construing a claim without

the respect due both a trial court's decision that a factual dispute underlies the meaning of a claim term and its resolution of that dispute.

Provided that no factual findings about disputed terms were necessarily made in the course of construing the claim, our making a claim construction that supersedes that of the district court is not inconsistent with the Court's opinion. See *Serrano v. Telular Corp., 111 F.3d 1578, 42 U.S.P.Q.2D (BNA) 1538 (Fed. Cir. 1997)* (construction of the claims involved no factual disputed between the parties); *International Communication Materials, Inc. v. Ricoh Co., 108 F.3d 316, 318-19, 41 U.S.P.Q.2D (BNA) 1957, 1958-59 (Fed. Cir. 1997); Alpex, 102 F.3d 1214* (using Alpex's expert testimony against Alpex, there were no factual dispute between the parties); *Metaullics Sys. Co. v. Cooper, 100 F.3d 938, 939, 40 U.S.P.Q.2D (BNA) 1798, 1799 (Fed. Cir. 1996); Insituform Techs., Inc. v. CAT Contracting, Inc., 99 F.3d 1098, 40 U.S.P.Q.2D (BNA) 1602 (Fed. Cir. 1996)* (attorney argument regarding claim construction presented no factual dispute about the technology); 1 S. Childress & M. Davis, Federal Standards of Review: Civil Cases and General Review Principles, §§ 2.13, 2.14 (2d ed. 1991). If this court does not believe the claim construction to be erroneous based on an independent review of the legal conclusions and a review of the constituent factual findings for substantial evidence, it must affirm. See *Bose Corp. v. Consumers Union of United States, 466 U.S. 485, 514 n.31, 80 L. Ed. 2d 502, 104 S. Ct. 1949 (1984);* see also *Pullman-Standard v. Swint, 456 U.S. 273, 287-88, 72 L. Ed. 2d 66, 102 S. Ct. 1781 (1982).*

This court may not, however, independently review the constituent facts or disregard the jury's findings, absent proof that they lack sufficient evidence that "a reasonable mind might accept as adequate to support" them. *Consolidated Edison Co. v. NLRB, 305 U.S. 197, 229, 83 L. Ed. 126, 59 S. Ct. 206 (1938);* see *Genentech, Inc. v. Wellcome Found. Ltd., 29 F.3d 1555, 1565, 31 U.S.P.Q.2D (BNA) 1161, 1169 (Fed. Cir. 1994).* Nor may we construe a claim in a manner that is

inconsistent with our function as a court of review; we cannot divine new interpretations of terms in a claim or make findings of fact from a record that cannot support them. See *Avia Group Int'l, Inc. v. L.A. Gear California, Inc., 853 F.2d 1557, 1561, 7 U.S.P.Q.2D (BNA) 1548, 1551 (Fed. Cir. 1988).*

Sometimes it may be necessary for an appellate court to pronounce new legal principles during an appeal. However, even if this court identifies a question of claim construction as one of law—though its resolution is relevant to only the particular litigation or document—it cannot elevate the activity to one of determining legal principles, as is for example, statutory construction. See *Markman, 116 S. Ct. at 1396* ("Issue preclusion could not be asserted against new and independent infringement defendants even within a given jurisdiction . . . ."); *In re Freeman, 30 F.3d 1459, 1466, 31 U.S.P.Q.2D (BNA) 1444, 1450 (Fed. Cir. 1994); Jackson Jordan, Inc. v. Plasser American Corp., 747 F.2d 1567, 1574-75, 224 U.S.P.Q. (BNA) 1, 5-6 (Fed. Cir. 1984)* (second alleged infringer not bound by prior claim construction unless it had, inter alia, a full and fair opportunity to litigate the construction in the first infringement action). Thus, regardless of the labels we attach to these questions, without the benefit of a full record from the trial court, it is neither the function of this court nor is it within our capacity as an appellate court to adopt new interpretations, most especially not if the interpretation under review is of terms informed by conflicting evidence. Such indiscriminate and conclusive review deprives the parties of important substantive and procedural mechanisms provided in the trial courts, where interpretation can be informed by additional discovery and expert testimony, and where it can be checked by appellate review as a matter of right. If claim construction is only a question of law to be reviewed by this court de novo, then the absence of review as a matter of right over our claim constructions, which may be new and unsupported by legal analysis, or may never have been tested by the adversarial process, would transform this court into a trial court of first and usually last resort.

II. METHOD OF REVIEW

To determine whether a patent has been infringed, a district judge must partake of a two-step analysis: (1) construction of the claims to determine their legal effect by examining and resolving, inter alia, factual disputes over the meaning and scope of technical words or terms of art used in the patent, see *Fromson, 132 F.3d at 1442, 45 U.S.P.Q.2D (BNA) at 1272; Markman, 52 F.3d at 999, 34 U.S.P.Q.2D (BNA) at 1347* (Newman, J., dissenting); and (2) a comparison of the properly construed claims to the accused device, see *Carroll Touch, Inc. v. Electro Mechanical Sys., Inc., 15 F.3d 1573, 1576, 27 U.S.P.Q.2D (BNA) 1836, 1839 (Fed. Cir. 1993).* The first step, construction of the claim, is ultimately a question for the judge. See *Markman, 116 S. Ct. at 1395* ("So it turns out here, for judges, not juries, are the better suited to find the acquired meaning of patent terms.") In construing the claims, a judge looks to the claims themselves, the specification, the prosecution history of the patent, see *Minnesota Mining and Mfg. Co., v. Johnson & Johnson Orthopaedics, Inc., 976 F.2d 1559, 1566, 24 U.S.P.Q.2D (BNA) 1321, 1327 (Fed. Cir. 1992),* and, if necessary, extrinsic evidence for information or to resolve disputes over the meaning of terms, see *Texas Instruments, Inc. v. United States Int'l Trade Comm'n, 988 F.2d 1165, 1171, 26 U.S.P.Q.2D (BNA) 1018, 1023 (Fed. Cir. 1993).* Although *Markman, 517 U.S. 370, 116 S. Ct. 1384, 134 L. Ed. 2d 577,* requires the judge to make the ultimate determination about the meaning and legal consequence of a claim, it does not prohibit him from submitting subsidiary factual disputes to a jury, even if it does not encourage it.

The judge follows the same first step to construe claims containing means-plus-function limitations under *35 U.S.C. § 112*(6) (1994). See *Alpex, 102 F.3d at 1220, 40 U.S.P.Q.2D (BNA) at 1672; Intellicall, Inc. v. Phonometrics, Inc., 952 F.2d 1384, 1388, 21 U.S.P.Q.2D (BNA) 1383, 1387 (Fed. Cir. 1992).* However, to complete the construction of these means-plus-function terms, the judge must look to the structures, materials, or acts disclosed in the patent's specifications and

to their equivalents. *Id., 952 F.2d at 1388, 21 U.S.P.Q.2D (BNA) at 1387.* To determine the scope of such equivalents, the district court must resolve questions of fact by resorting to the expertise of the fact finder. Cf. *Markman, 52 F.3d at 977 n.8, 34 U.S.P.Q.2D (BNA) at 1337, n.8* (expressly declining to reach "the issue of whether a determination of equivalents under § 112, para. 6 is a question of law or fact"); *In re Hayes Microcomputer Prods., Inc., 982 F.2d 1527, 1541-43, 25 U.S.P.Q.2D (BNA) 1241, 1253 (Fed. Cir. 1992)* ("This list [of factors that may be considered when determining the scope of a means-plus-function limitation] is not exhaustive and reasonable inferences by the fact finder are appropriate."); *King Instrument Corp. v. Otari Corp., 767 F.2d 853, 862-63, 226 U.S.P.Q. (BNA) 402, 408-09 (Fed. Cir. 1985); Palumbo v. Don-Joy Co., 762 F.2d 969, 975-76, 226 U.S.P.Q. (BNA) 5, 8 (Fed. Cir. 1985)* ("Whether that accused device is a § 112 equivalent . . . is a question of fact."); *D.M.I., Inc. v. Deere & Co., 755 F.2d 1570, 1575, 225 U.S.P.Q. (BNA) 236, 239 (Fed. Cir. 1985).* For pragmatic reasons, the resolution of this factual determination is often made at the same time the fact finder determines infringement (step two, described below).

The second step of the infringement analysis requires a factual comparison of the claimed invention to the accused device, which is done by the fact finder. See *Winans v. Denmead, 56 U.S. (15 How.) 330, 338, 14 L. Ed. 717 (1853).* To prove literal infringement, the patentee must show that the accused device contains every limitation in the asserted claims. See *Dolly, Inc. v. Spalding & Evenflo Cos., 16 F.3d 394, 397, 29 U.S.P.Q.2D (BNA) 1767, 1769 (Fed. Cir. 1994).* If tried to a jury, it is the jury's factual findings on infringement that are reviewed by this court for lack of substantial evidence, see *Genentech, 29 F.3d at 1565, 31 U.S.P.Q.2D (BNA) at 1168-69,* as part of this court's reapplication of the standard for judgment as a matter of law.

A claim of infringement under the doctrine of equivalents modifies this second step by requiring that the fact finder

determine whether differences between particular elements of the accused device and the asserted claims are insubstantial. See *Warner-Jenkinson Co. v. Hilton Davis Chem. Co., 137 L. Ed. 2d 146, 117 S. Ct. 1040, 1054* (Mar. 3, 1997). However, because they have separate origins, purposes, and applications, determining equivalence under paragraph 112(6) requires an analysis different from that used to determine equivalence under the doctrine of equivalents. See *Alpex, 102 F.3d at 1222, 40 U.S.P.Q.2D (BNA) at 1673* ("Under § 112, the concern is whether the accused device, which performs the claimed function, has the same or an equivalent structure as the structure described in the specification corresponding to the claim's means. Under the doctrine of equivalents, on the other hand, the question is whether the accused device is only insubstantially different than the claimed device.") (internal citations omitted).

After the judge construes the means-plus-function limitations identifying structures, materials, or acts described in the patent's specification, and their equivalents as determined by the fact finder (step one, described above), the judge gives the construed claims to the fact finder, in this case a jury, for a determination of infringement. See *D.M.I., 755 F.2d at 1575, 225 U.S.P.Q. (BNA) at 239.* For literal infringement, the fact finder must determine whether the accused device performs an identical function to the one recited in the means-plus-function clause. See *Pennwalt Corp. v. Durand-Wayland, Inc., 833 F.2d 931, 934, 4 U.S.P.Q.2D (BNA) 1737, 1739 (Fed. Cir. 1987)* (if the identical function is not performed, literal infringement is not possible). If the identical function is performed, the fact finder must then determine whether the accused device utilizes the same structure or materials as described in the specification, or their equivalents.

Just as the fact finder's infringement analysis differs between equivalence under paragraph 112(6) and the doctrine of equivalents, so too differs the analytical effect of statements made during the prosecution of the patent on construction of the claims. Under paragraph 112(6), a statement

made during prosecution may confine the range of equivalent structures, materials, or acts that are directly claimed by the patent. However, in the context of a doctrine of equivalents analysis, the patentee seeks protection beyond that claimed by the patent directly. As such, the judge's construction of the claims—which includes the interpretation of claim terms—may not be sufficient to remove from the jury's consideration all subject matter that was disclaimed during prosecution.

Prosecution history estoppel addresses this problem by excluding equivalents surrendered during prosecution. Under this doctrine, statements made to overcome rejections based, as here, on prior art estop the patentee from extending its right to exclude others from making, using, or selling subject matter known to be insubstantially different from, or interchangeable with, claimed elements at the time of the alleged infringement. *Warner-Jenkinson, 117 S. Ct. at 1053.* Although both forms of equivalence require the district court to examine the prosecution history as part of its construction of the claims, under the doctrine of equivalents, the judge gives the claim, properly construed to exclude disclaimed subject matter, to the jury and then, where appropriate, also instructs the jury on the possible range of equivalents that it may or may not consider due to prosecution history estoppel.

III. REVIEW

As depicted in figure two of the patent, ante at 3 [maj. opn], the '837 patent discloses a dual-stage pump. It claims a first pumping means that pumps fluid through a filtering means "to" a "second pumping means." It also claims a "means to enable said second pumping means to collect and/or dispense the fluid, or both," at rates or during periods that are independent of the operation of the first pumping means. As a result of this structure, the pump described in the '837 patent is able to accumulate fluid for later dispense, dispense fluid immediately, or partially accumulate and partially dispense fluid in precise measurements and at precise times.

The preferred embodiment describes a second pumping means where the second pump collects and dispenses the fluid from its own internal reservoir.

Like the pump disclosed in the '837 patent, Cybor Corporation's Model 5226 dual-stage pump also allows users to pump or dispense highly accurate amounts of liquid chemicals in increments as small as 0.1 microliter. Both pumps are primarily used for accurately dispensing chemicals—such as photoresist and polimide—onto semiconductor wafers during their fabrication.

Of relevance to this appeal, in construing the '837 patent the district judge interpreted the disputed term "to" and submitted the term to the jury for a determination of infringement. The judge also submitted the terms "second pumping means," "means to enable said second pumping means," and "or both" to the jury as means-plus-function terms, along with structures in the '837 patent's specification, for a determination of infringement. The judge left the task of considering prosecution history estoppel to the jury.[11]

The jury found that Cybor's Model 5226 pump literally infringed claims 1-10, 13-15, and 17-20, and that it infringed claims 11, 12, and 16 under the doctrine of equivalents. It is unclear which combination of components in Cybor's Model 5226 pump the jury found to infringe claims 1-10, 13-15, and 17-20. It may have interpreted "second pumping means" in such a way that it found either Cybor's second pump or the combination of its second pump and its external reservoir to be equivalent structures to those provided in the specification of the '837 patent corresponding to the "second pumping means." Likewise, the jury may have interpreted "means to enable said second pumping means" in such a way that it

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[11] Although having a jury make a legal determination of the effect of statements made during prosecution of the patent is error, alone this error was harmless because to find infringement, the jury must have arrived at the same legal conclusion that we did on appeal: that the prosecution history does not exclude Cybor's external reservoir from the jury's consideration of equivalents under paragraph 112(6).

found either Cybor's external reservoir or the combination of its external reservoir and its second pump to be equivalent structures to those provided in the specification of the '837 patent corresponding to the "means to enable said second pumping means." In total, there are five possible combinations of claim term interpretations and findings of paragraph 112(6) equivalents that would have led the jury to its infringement verdict.

Cybor renewed its earlier motion for judgment as a matter of law pursuant to Rule 50(b) and for a new trial pursuant to Rule 59 of the Federal Rules of Civil Procedure, on the basis that no reasonable juror could find that its pump infringes the '837 patent. The court denied the motion, finding "that the jury's infringement verdict is supported by the evidence . . . the jury instructions were proper and the verdict was not against the clear weight of the evidence or contrary to the instructions." Cybor moved for reconsideration, arguing that this court's then recently issued *Markman, 52 F.3d 967, 34 U.S.P.Q.2D (BNA) 1321*, required that the judge, and not the jury, interpret all the claims. The district court denied the motion and entered final judgment, from which Cybor appealed.

On appeal, Cybor argues that had the district court properly analyzed the prosecution history of the '837 patent, it would have excluded reservoir structures like Cybor's from consideration as an equivalent under paragraph 112(6). Cybor further argues that the judge would have instructed the jury not to consider its reservoir when determining whether Cybor's second pump has the same or an equivalent structure as the structure in the portions of the '837 patent's specification corresponding to the second pumping means. Without its reservoir, Cybor argues that its second pump cannot infringe the "second pumping means" limitation, the "or both" functional limitation, or the filter means "to" second pumping means limitation. Cybor also argues that the district judge erred in failing to identify the corresponding structures in the specification, and in permitting the judge to consider

the effect of statements made during prosecution of the '837 patent.

FAS responds that the district court properly considered and rejected Cybor's argument about the prosecution history of the '837 patent, that it properly construed the necessary claims, and that it properly submitted them along with relevant corresponding structures—as described in the specification—to the jury for a determination of infringement. FAS further argues that the district court was not obliged, either before or after Markman, to submit complete claim constructions to the jury so long as the judge's ultimate claim construction is supported by the jury's factual findings, presumed or expressed, regarding disputed claim terms, and so long as the judge later evaluates and sustains the jury's factual findings.

Claim 1 of the '837 patent contains three disputed limitations and is representative of how these limitations are used, where they appear throughout the 20 asserted claims:

In a device for filtering and dispensing fluid in a precisely controlled manner, the combination of:

> first pumping means;
>
> second pumping means in fluid communication with said first pumping means; and filtering means between said first and second pumping means, whereby said first pumping means pumps the fluid through said filtering means to said second pumping means;
>
> in which each of said first and second pumping means includes surfaces that contact the fluid, said surfaces being of materials that are non-contaminating to industrial fluids which are viscous and/or high purity and/or sensitive to molecular shear; and comprising means to enable said second pumping means to collect and/or dispense the fluid, or both, at rate or during periods of operation, or both which are independent of rates or periods of operation, or both, respectively, of said first pumping means.

'837 patent, col. 9, lines 45-61 (emphasis and formatting added). The specification of the '837 patent further describes the "second pumping means" as having tubing that connects the pump to the second incremental pump advancement means, col. 5, lines 49-52, a diaphragm inside the second pump, col. 6, lines 2-3, and a separate inlet passage and outlet passage, col. 7, lines 10-20.

During prosecution, the inventors further limited the scope by making the following statements to overcome a prior art rejection that the claimed invention was unpatentable over Storkebaum et al., U.S. Patent No. 4,749,476.

> Additionally, Storkebaum specifically provides a separate container 12 for collecting the permeate. Obviously, Storkebaum does not teach the collection of fluid in a second pumping means. . . . Storkebaum discloses a permeate collecting container 12 that is separate from the conveying pump 13. Nothing in Storkebaum discloses or makes obvious the claimed invention, nor the precise and flexible control provided by the second pump means of Claim 1.

Given the nature and function of the Storkebaum container, these statements were made to distinguish the invention over the prior art. They confine the possible interpretation of terms in the claims under paragraph 112(6) and they may prevent FAS's desired use of the doctrine of equivalents. See *Warner-Jenkinson, 117 S. Ct. at 1051 n.7.* However, in this case the limitation of possible equivalents extends only so far as was necessary to distinguish aspects of the invention's "second pumping means" from Storkebaum's external container. The statements do not require that the district judge provide the jury with more specific interpretations of claim terms because the inventors disclaimed the use of a separate, physically unattached reservoir that cannot achieve differential pumping rates between the two pumps by accumulating fluid in a reservoir—the function performed by the '837 patent's "means to enable said second pumping means."

Storkebaum's separate container collects permeate and vents the fluid; it is designed to feed a conveying pump that

is part of a big circulation loop, not a fluid dispensing device. Because the inventors never disclaimed an external reservoir that accumulates fluid to permit different pumping rates and because equivalence under paragraph 112(6) is a question of fact, the district court properly permitted the jury to consider the structure of Cybor's external reservoir as a possible equivalent, under paragraph 112(6), to structures in the '837 patent's specification that define the "second pumping means" and the "means to enable the second pumping means." It was also proper for the district court to permit the jury to consider Cybor's reservoir in measuring the substantiality of differences between its device and the invention claimed by the '837 patent, under the doctrine of equivalents.

A. "Second Pumping Means"

"Means to Enable Said Second Pumping Means"

As to these two disputed limitations, each of the independent claims, except for claim 16, uses the term "second pumping means," which the court interpreted in means-plus-function language as: "a structure identical to the structure disclosed in the specification of the patent or the equivalent of that structure which performs the function of a fluid accumulator/dispense pump." The district court also interpreted the term "means to enable said second pumping means," which appears in each of the independent claims except claims 10, 16, and 17, in means-plus-function language, as: "a structure identical to the structure disclosed in the specification of the patent, or the equivalent thereof, which allows the second pumping means to [accumulate, dispense, and partially collect and dispense fluid at rates and during periods independent of the first pumping means]."

Cybor argues that these means-plus-function elements should be limited to the exact structures disclosed in the claims and the specification of the '837 patent. However, paragraph 112(6) permits the disclosure of specific structures in the specification, without limiting protection to the disclosed structures. See *35 U.S.C. P 112*(6) ("Such claims shall

be construed to cover the corresponding structure, materials, or acts described in the specification and equivalents thereto."); *D.M.I., 755 F.2d at 1574, 225 U.S.P.Q. (BNA) at 238.* Cybor is correct that the reservoir and the second pump in its dual-stage pump are not identical to the structure disclosed in the specification of the '837 patent; they contain a valve unlike the disclosed structure, and if uncoupled from the attached reservoir, the pump does not permit the partial accumulation and partial dispensing of fluid as contemplated by the term "flow through" in the '837 patent. However, as explained above, the prosecution history does not require the district court to uncouple the valve or separate the reservoir from the second pump before submitting the terms "second pumping means" and "means to enable said second pumping means" to the jury. The '837 patent's preferred embodiment shows the reservoir inside the second pump, but nothing requires such a restriction, and limitations in the specification should not be read into the claims. See *Constant v. Advanced Micro-Devices, Inc., 848 F.2d 1560, 1570-71, 7 U.S.P.Q.2D (BNA) 1057, 1064 (Fed. Cir. 1988).* Finally, such a restriction would go against the clear weight of testimony submitted by FAS's expert witnesses, Clark, who was qualified as one skilled in the art of fluid dynamics, and Snodgrass and Gibson.

"As in all cases involving assertions of equivalency, wherein the patentee seeks to apply its claims to structures not disclosed by the patentee, the court is required to exercise judgment." *Texas Instruments, Inc. v. United States Int'l. Trade Comm'n, 846 F.2d 1369, 1371, 6 U.S.P.Q.2D (BNA) 1886, 1889 (Fed. Cir. 1988).* Here, the district court exercised its judgment, made a partial, though legally sufficient interpretation of these limitations, and presented them to the jury for resolution of factual disputes on the way to determining equivalents under paragraph 112(6). Based on these interpretations and the jury's verdict, we presume[12] that the jury

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[12] Findings of fact are presumed where they would be necessary to support a jury's verdict. See *Perkin-Elmer Corp. v. Computervision*

found that the combination of one of Cybor's Model 5016 pumps with the external reservoir it uses in its Model 5226 pump created a structural equivalent to the "second pumpiing means" or the "means to enable said second pumping means" claimed in the '837 patent and described by the specification under paragraph 112(6). Because we have not been shown that the jury lacked substantial evidence to support this finding of equivalents or infringement, we must affirm.

However, if the court is correct that claim construction is purely and solely a question of law to be reviewed de novo on appeal, it could not affirm the judgment of infringement. Infringement was determined in this case by a jury at the same time that it was asked to construe these claims by resolving factual disputes about their meaning and to determine whether the scope of these claims should be limited by arguments made during prosecution of the patent. Ordinarily, a jury's verdict of infringement permits us to presume the existence of factual findings necessary to that verdict. But we are in no way entitled to presume factual findings or even to rely on the verdict of infringement where neither the jury, nor the judge on a motion for judgment as a matter of law, articulated a construction of the claims upon which the findings are premised. As explained above, there are five possible combinations of claim term interpretations and findings of paragraph 112(6) equivalents that could have led the jury to its infringement verdict. In light of the possibilities, it is difficult to imagine how the court can affirm the jury's finding of infringement based upon its own de novo claim construction, which merely presumes a claim construction by the dis-

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Corp., 732 F.2d 888, 893, 221 U.S.P.Q. (BNA) 669, 673 (Fed. Cir. 1984) ("To facilitate review on a motion for [judgment as a matter of law] and on appeal, it is preferred that a jury be provided with special interrogatories designed to reveal more clearly the findings it made. Absent such interrogatories, the law presumes the existence of findings necessary to support the verdict the jury reached."); see also *Railroad Dynamics, Inc. v. A. Stucki Co., 727 F.2d 1506, 1516, 220 U.S.P.Q. (BNA) 929, 939 (Fed. Cir. 1984).*

trict court and that admits of no deference to the findings of fact.

The effect of allowing such a combination of presumptions in this case has been to deny Cybor meaningful review of anything more than the district judge's decision not to apply prosecution history estoppel, since it was the only legal determination that can be located outside of those presumptions. Not surprisingly, this is the decision Cybor contests most strenuously on appeal. The effect has also been to allow this court to presume that it made the same claim construction as the jury, without so much as articulating its own construction of these two claim terms, and then to presume that the jury's infringement finding is still valid. Penultimately, Cybor is left with little more than the ability to make presumptions as to our own claim interpretations in any motion it may file for reconsideration. Worse still is the message the court is sending to district courts: we will affirm a finding of infringement as long as the district court avoids articulating its construction of the claims—which coincidentally leaves us free to arrive at our own constructions—and as long as we can presume that the jury used our constructions to arrive at that finding of infringement.

B. "To"

The second of these three disputed claim limitations, "pumps fluid through said filtering means to said second pumping means," is the only one that the district court did not analyze as part of a means-plus-function limitation. Cybor argued that the fluid has to be pumped directly to the second pump. FAS maintains that it is enough that the fluid merely reaches the second pump. The district court interpreted the term "to" as pumping "towards and with a destination of" the second pump and left the determination of infringement to the jury. Absent its prosecution history estoppel argument, there remains little to Cybor's interpretation of this claim limitation. FAS presented sufficient expert testimony from Gibson and Clark that the fluid must merely be pumped "ultimately"

to the "second pumping means." This evidence is consistent with the expert testimony of Snodgrass and Gibson that the "to" limitation requires only a designed or dedicated pathway between the two pumping means, which Cybor's device possesses. Because all experts were consistent in their testimony about the meaning of terms to one skilled in the art, there was no occasion here for the court to resolve a factual dispute over the meaning of a term en route to their interpretation. Moreover, because the interpretation of this claim limitation describes Cybor's Model 5226 dual-stage pump, regardless of whether or not the reservoir is part of the second pumping means, no reasonable juror could use this as a basis for finding noninfringement, and I agree we can affirm this aspect of the district court's judgment.

C. "Or Both"

The third disputed limitation, "or both" is contained within means-plus-function language, it describes a function of the "means to enable second pumping means," and it must be a function of Cybor's device if the fact finder is to consider equivalence under paragraph 112(6). Cybor argues solely that the inventor of the '837 patent disclaimed external reservoirs such as its own, by distinguishing Storkebaum. Thus the jury should not consider its external reservoir when it determines whether the Model 5226 dual-stage pump contains structural equivalents to each of the relevant limitations disclosed in the '837 patent. Given the prosecutionhistory analysis and the jury's presumed finding that Cybor's reservoir and second pump contain equivalents of all the limitations to the "means to enable said second pumping means," Cybor's argument cannot stand. The jury had substantial evidence upon which to find that Cybor's reservoir and second pump together can collect, dispense, and both collect and dispense fluid, so its finding of infringement is also sufficient.

IV. JUDGMENT AS A MATTER OF LAW

Finally, Cybor argues that *Markman, 52 F.3d 967, 34 U.S.P.Q.2D (BNA) 1321,* requires that the judge determine the meaning of the claim before submitting it to the jury. However, that opinion said that the judge must determine the meaning of a claim, but that the meaning need not be established before the claims are submitted to the jury. *Markman, 52 F.3d at 981, 34 U.S.P.Q.2D (BNA) at 1331* (pronouncing the meaning of a claim "ordinarily can be accomplished by the court in framing its charge to the jury, but may also be done in the context of dispositive motions such as those seeking judgment as a matter of law.") The risk of waiting, of course, is that the jury's deliberative efforts on infringement may be rendered useless if the instruction was improper and the affected factual dispute was material to the verdict. Here, this happens only under the court's standard of review. Moreover, given the nature and interrelatedness of these disputed limitations and the underlying factual questions—whether the combination of Cybor's second pump and its reservoir is a paragraph 112(6) equivalent to the "second pumping means" or the "means to enable said second pumping means"—it is difficult to see how the district court could have better instructed the jury, absent the use of detailed and alternative special verdicts. Therefore, I see no reversible error in the district court's limited claim interpretations or its denial of Cybor's motion for judgment as a matter of law.

RADER, Circuit Judge, dissenting from the pronouncements on claim interpretation in the en banc opinion, concurring in the judgment, and joining part IV of the en banc opinion.

The en banc court chooses this case, resolvable under the prosecution history estoppel doctrine, to state that it accords no deference to the district court's central role in patent litigation, namely claim interpretation. Yet, based on this court's

unanimous concurrence in the judgment, the standard of review does not affect the outcome in this case. Accordingly, this case obscures what really is at stake when claim construction is subject to de novo review and appellate revision.[13]

In Markman I, this court en banc declared that claim interpretation resides solely with the judge. The Supreme Court agreed. See *Markman v. Westview Instruments, Inc., 517 U.S. 370, 116 S. Ct. 1384, 1387, 134 L. Ed. 2d 577 (1996)* (Markman II). By removing lay juries from complex technological decisions, these decisions promised to improve the predictability and uniformity of patent law. See *Markman II, 116 S. Ct. at 1396.*

To evade the strictures of the Seventh Amendment, Markman I necessarily reasoned that claim construction is purely a matter of law. As a pure question of law, claim construction became subject to plenary appellate review. Because jury involvement remained the focus of Markman I, the Supreme Court did not address appellate review of claim construction. Instead the Supreme Court repeatedly intimated that claim construction was not a purely legal matter. See, e.g., *Mark-*

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[13] In fact, the district court submitted this case to a jury before this court decided *Markman v. Westview Instruments, Inc., 52 F.3d 967, 979, 34 U.S.P.Q.2D (BNA) 1321, 1329 (Fed. Cir. 1995)* (Markman I). Thus, the district court's jury instructions only partially construed the claims, and the en banc opinion relies, as it must, upon what it presumes must have been the jury's claim construction. Nor did the district court deliberately accept and rely upon expert testimony to understand and interpret the claim terms, a central issue in Markman I. Heedless of these problems, this court has selected this case for en banc review. *Fromson v. Anitec Printing Plates, Inc., 132 F.3d 1437, 45 U.S.P.Q.2D (BNA) 1269 (Fed. Cir. 1997),* may have been a more suitable choice for meaningful en banc consideration of the issue of appellate deference in claim construction. The district court decided Fromson by applying the Markman I regime. The Fromson district court also relied upon extrinsic evidence and findings of scientific/technologic fact to interpret the meaning of claim terms to one of ordinary skill in the art at the time of the invention (over twenty years ago). Thus, the facts of Fromson might have better illustrated how different standards of review can direct the outcome on appeal.

man II, 116 S. Ct. at 1390 (calling the construction of a term of art following receipt of evidence a "mongrel practice"); id. at 1395 (suggesting that claim interpretation " 'falls somewhere between a pristine legal standard and a single historical fact' " (quoting *Miller v. Fenton, 474 U.S. 104, 114, 88 L. Ed. 2d 405, 106 S. Ct. 445 (1985)*)); id. at 1396 ("notwithstanding [claim construction's] evidentiary underpinnings"). Nonetheless, in the time since Markman II, this court has repeatedly extolled its own authority to "review the issue of claim interpretation independently without deference to the trial judge." *Exxon Chem. Patents, Inc. v. Lubrizol Corp., 64 F.3d 1553, 1556, 35 U.S.P.Q.2D (BNA) 1801, 1803 (Fed. Cir. 1995)* (Lubrizol) (emphasis added); see also *Hoechst Celanese Corp. v. BP Chem. Ltd., 78 F.3d 1575, 1578, 38 U.S.P.Q.2D (BNA) 1126, 1128* (Fed. Cir.), cert. denied, *136 L. Ed. 2d 198, 117 S. Ct. 275 (1996)*. Indeed, at one point, this court noted that its law requires "independent determination of the construction of the claims, as a matter of law, unencumbered by the trial process." *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 72 F.3d 857, 863, 37 U.S.P.Q.2D (BNA) 1161, 1165 (Fed. Cir. 1995)*, vacated and remanded on other grounds, *117 S. Ct. 1240, 137 L. Ed. 2d 323 (1997)*. Unencumbered by the trial process? Far from an encumbrance, the Supreme Court suggests that the trial should be the "main event." *Wainwright v. Sykes, 433 U.S. 72, 90, 53 L. Ed. 2d 594, 97 S. Ct. 2497 (1977)*.

Because jury issues dominated Markman I, this court has yet even to receive briefing and oral argument on the proper standard of review for a trial court's claim construction. Nonetheless this court relies on its earlier en banc decision, *Markman I, 52 F.3d at 979*, to make claim construction purely a question of law, subject to independent appellate review without deference to or encumbrance by the trial process. To my eyes, this rejection of the trial process as the "main event" will undermine, if not destroy, the values of certainty and predictability sought by Markman I.

I.

The question of the proper standard of review seems an esoteric legal topic of interest only to law professors and appellate judges. In most cases, however, the review standard influences greatly both the trial judges who preside over the trial process and patent practitioners who must advise clients to accommodate their business plans to an uncertain legal regime.

From the vantage point of trial judges, Markman I dictates many deviations from the normal procedural course for litigation.[14] Perhaps the central deviation, however, affects the

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[14] The following is an incomplete list of procedural deviations required by Markman I:

1. Multiple trials, problem I: If hearings are necessary to interpret complex claims, the trial court must set aside time in its crowded docket for one proceeding to interpret claims and a second (potentially with a jury) to determine infringement and other issues.

2. Claim interpretation, problem I: Fearing that it may not receive the opportunity to supplement expert reports or reopen discovery after the judge's interpretation, a party often argues alternative claim construction theories from the outset of litigation. This extends the time and expense of the claim interpretation proceedings.

3. Bias toward summary judgments: In practical terms, Markman I directs the proceedings toward summary judgment on the central issue of the litigation at a potentially premature stage of issue development. Prematurely addressing issues, even at the appellate level, can result in expensive repetition of effort. See *CVI/Beta Ventures, Inc. v. Tura LP, 112 F.3d 1146, 1157-58, 1160 n.7, 42 U.S.P.Q.2D (BNA) 1577, 1585, 1587 n.7 (Fed. Cir. 1997)* (finding error in a claim construction that had been affirmed in an earlier appeal), cert. denied, *118 S. Ct. 1039 (1998)*.

4. Claim interpretation, problem II: As soon as the trial court issues a claim interpretation, both sides often seek to shift their original claim interpretations to accommodate the judge's views. Thus, the parties seek to revise expert reports or reopen discovery to account for the judge's interpretation. This maneuvering leads to procedural battles over surprise and motions for additional time to prepare for trial. See *Loral Fairchild Corp. v. Victor Co., 906 F. Supp. 798 (E.D.N.Y. 1995)* (interpreting claims); *Loral Fairchild Corp. v. Victor Co., 911 F. Supp. 76, 80-81*

trial court's discretion to use expert testimony. When confronted with sophisticated technology, district court judges often seek testimony from experts to help them understand and interpret the claim. Under the guise of setting standards for claim construction, this court instructs experienced trial judges that they may use experts to understand, but not to interpret, the claim terms. As a matter of logic, this instruction is difficult to grasp. What is the distinction between a trial judge's understanding of the claims and a trial judge's interpretation of the claims to the jury? Don't judges instruct the jury in accordance with their understanding of the claims? In practice, how does this court's lofty appellate logic work? As this court acknowledges, a trial court must often resort to experts to learn complex new technologies. See, e.g., *Markman I, 52 F.3d at 986.* What happens when that learning

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(E.D.N.Y. 1996) (preventing plaintiff from changing theory of infringement in response to claim interpretation).

5. The new evidence dilemma: As a result of the new and perhaps somewhat unexpected interpretation, the parties scramble to create and acquire new evidence for their infringement arguments.

6. The learning curve problem: Like all human endeavors, claim interpretation is a learning process. The trial judge makes every effort to state the precise scope of the claims at the close of the initial proceeding, but often, with the additional learning during the infringement trial, realizes that the initial interpretation was too broad or too narrow in some respects. The judge then faces the dilemma of changing the rules in the middle of the game.

7. The judge as a trial issue: With the judge's claim interpretation central to the issues of infringement, trial counsel will try to exploit the judge's stature with the jury to show that the court is on their side.

8. Multiple trials, problem II: In the words of United States District Court Judge Roderick McKelvie: "In spite of a trial judge's ruling on the meaning of disputed words in a claim, should a three-judge panel of the Federal Circuit disagree, the entire case could be remanded for retrial on [a] different [claim interpretation]." *Elf Atochem North Am., Inc. v. Libbey-Owens-Ford Co., 894 F. Supp. 844, 857, 37 U.S.P.Q.2D (BNA) 1065, 1075 (D. Del. 1995).*

Trial judges can often address each of the above with careful case management, but at the cost of expending scarce trial court resources.

influences a trial judge's interpretation of the claim terms? Are trial judges supposed to disguise the real reasons for their interpretation? How will this perverse incentive to "hide the ball" improve appellate review?

As a matter of legal analysis, the en banc court's direction to trial judges is equally hard to justify. The objective of claim interpretation is to discern the meaning of the claim terms to one of ordinary skill in the art at the time of invention. See *Multiform Desiccants, Inc. v. Medzam, Ltd., 133 F.3d 1473, 1477, 45 U.S.P.Q.2D (BNA) 1429, 1432 (Fed. Cir. 1998)* ("It is the person of ordinary skill in the field of the invention through whose eyes the claims are construed."). What then defeats the relevance of the testimony of one of skill in the art at the time of invention? Of course this relevant testimony must not conflict with or attempt to trump contemporaneous intrinsic evidence from the patent document itself, see *Vitronics Corp. v. Conceptronic, Inc., 90 F.3d 1576, 1582-83, 39 U.S.P.Q.2D (BNA) 1573, 1576-77 (Fed. Cir. 1996)*, but both trial and appellate judges are poised to halt that abuse. Moreover, by assigning claim interpretation to the judge, Markman II has already corrected the major source of the problem with experts, namely their ability to influence lay jurors with the strength of their resumes rather than the strength of their reasoning. In any event, it seems a contradiction to bar those of skill in the art at the time of invention from a search for the meaning of terms to one of skill in the art at the time of the invention. In effect, the en banc opinion has sub silentio redefined the claim construction inquiry as "how a lawyer or judge would interpret the term."

District courts have already expressed their frustration with the strictures of Markman I:

> When two experts testify differently as to the meaning of a technical term, and the court embraces the view of one, the other, or neither while construing a patent claim as a matter of law, the court has engaged in weighing evidence and making credibility determinations . . . . But when the Federal Circuit Court of Appeals states

> that the trial court does not do something that the trial court does and must do to perform the judicial function, the court knowingly enters a land of sophistry and fiction.

Lucas Aerospace, Ltd. v. Unison Indus., LP, 890 F. Supp. 329, 333-34 n.7, 36 U.S.P.Q.2D (BNA) 1235, 1239 n.7 (D. Del. 1995); see also *Elf Atochem North Am., Inc. v. Libbey-Owens-Ford Co.*, 894 F. Supp. 844, 857, 37 U.S.P.Q.2D (BNA) 1065, 1075 (D. Del. 1995); In re Mahurkar Double *Lumen Hemodialysis Catheter Patent Litigation*, 831 F. Supp. 1354, 1359, 28 U.S.P.Q.2D (BNA) 1801, 1805 (N.D. Ill. 1993) ("Judges should not pretend that all nominally 'legal' issues may be resolved without reference to facts. . . . What seems clear to a judge may read otherwise to [one skilled in the art].").

II.

From the patent practitioner's standpoint, this court's enthusiastic assertion of its unfettered review authority has the potential to undercut the benefits of Markman I. Markman I potentially promised to supply early certainty about the meaning of a patent claim. This certainty, in turn, would prompt early settlement of many, if not most, patent suits. Once the parties know the meaning of the claims, they can predict with some reliability the likelihood of a favorable judgment, factor in the economics of the infringement, and arrive at a settlement to save the costs of litigation.[15] Mark-

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[15] Three variables affect the settlement calculus of each party to litigation: p, the probability of the plaintiff obtaining damages; J, the expected value of a judgment for the plaintiff; and c, the cost of litigation. See Richard A. Posner, The Federal Courts: Challenge and Reform 89-94 (1996). If $p \times J$ (pJ) exceeds c, then plaintiff will sue. The plaintiff values the case at pJ – c. If the defendant agrees on the values assigned to the variables, the suit will cost him pJ – c. This rough model poses an interesting question. Because the costs of litigation invariably exceed the costs of settlement, why do not all cases settle? Chief Judge Posner answers: "Uncertainty as to outcome is the key to the settlement

man I promised to provide this benefit early in the trial court process. To provide fairness under the Markman I regime, trial judges would provide claim interpretations before the expense of trial. Patent practitioners would then be armed with knowledge of the probable outcome of the litigation and could facilitate settlement.

The problem with this plan was in its implementation because as a question of law, claim interpretation is subject to free review by the appellate court. The Federal Circuit, according to its own official 1997 statistics, reversed in whole or in part 53% of the cases from district courts (27% fully reversed; 26% reversed-in-part). Granted this figure deals with all issues in cases with many issues. Nonetheless, one study shows that the plenary standard of review has produced reversal, in whole or in part, of almost 40% of all claim constructions since Markman I.[16]

A reversal rate in this range reverses more than the work of numerous trial courts; it also reverses the benefits of Markman I. In fact, this reversal rate, hovering near 50%, is the worst possible. Even a rate that was much higher would provide greater certainty.

Instead, the current Markman I regime means that the trial court's early claim interpretation provides no early certainty at all, but only opens the bidding. The meaning of a claim is

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rate . . . ." Id. at 90. This uncertainty leads each party to overestimate its chance of prevailing. Accordingly, each party will assign different values to the variables, most notably p, thereby diminishing the likelihood of settlement.

[16] This figure is based on a survey of every patent decision rendered by the Court of Appeals for the Federal Circuit between 5 April 1995 (the date Markman I was decided) and 24 November 1997. A total of 246 patent cases, originating in the Board of Patent Appeals and Interferences (BPAI), the district courts, and the Court of Federal Claims, were evaluated. Of the 246 cases, 141 cases expressly reviewed claim construction issues. Among these 141 decisions, this court reversed, in whole or in part, 54 or 38.3% of all claim constructions. With respect to the district court and Court of Federal Claims cases, the rate of reversal of claim constructions is 47 out of 126 or 37.3%.

not certain (and the parties are not prepared to settle) until nearly the last step in the process—decision by the Court of Appeals for the Federal Circuit. To get a certain claim interpretation, parties must go past the district court's Markman I proceeding, past the entirety of discovery, past the entire trial on the merits, past post trial motions, past briefing and argument to the Federal Circuit—indeed past every step in the entire course of federal litigation, except Supreme Court review. In implementation, a de novo review of claim interpretations has postponed the point of certainty to the end of the litigation process, at which point, of course, every outcome is certain anyway.

In practical terms, this implementation record has other perverse effects. Trial attorneys must devote much of their trial strategy to positioning themselves for the "endgame"—claim construction on appeal. As the focus shifts from litigating for the correct claim construction to preserving ways to compel reversal on appeal, the uncertainty, cost, and duration of patent litigation only increase. Thus, the en banc court's de novo regime belies the purpose and promise of Markman I.

Several high profile appeals have illustrated the problem created by the Federal Circuit's high reversal rate. In *Lubrizol, 64 F.3d 1553,* and *J.T. Eaton & Co. v. Atlantic Paste & Glue Co., 106 F.3d 1563, 41 U.S.P.Q.2D (BNA) 1641 (Fed. Cir. 1997),* this appellate court rejected not only the trial judge's claim reading, but also the readings advocated by both parties at trial and the readings advocated by all experts in the trial. In fact, in Eaton, the Federal Circuit did not base its interpretation on the specification or the totality of the prosecution history, but instead found its meaning in a brief excerpt from the affidavit of a single expert witness at the end of a lengthy prosecution. See *106 F.3d at 1568, 1570.* If the parties might succeed in convincing the Federal Circuit to reverse an entire trial result with an argument never presented to the trial court or with a brief excerpt from hundreds of pages of prosecution (again not presented to the trial court),

would they be wise to settle after a trial court's reading of the claims?

One other case makes the point even more persuasively. In *CVI/Beta Ventures, Inc. v. Tura LP, 112 F.3d 1146, 42 U.S.P.Q.2D (BNA) 1577 (Fed. Cir. 1997)* (Tura), the Federal Circuit reversed its own earlier claim interpretation as a question of law when the defendant and stage of the proceedings changed. On a motion for a preliminary injunction in an infringement action, a Maryland district court interpreted the 3% elasticity limitation in a claim for flexible eyeglass frames. On appeal the Federal Circuit reviewed this claim interpretation as a question of law and affirmed in a nonprecedential opinion. See *CVI/Beta Ventures, Inc. v. Custom Optical Frames Inc., 1996 U.S. App. LEXIS 14763, 1996 WL 338388* (Fed. Cir. June 19, 1996) (nonprecedential); see also *Tura, 112 F.3d at 1160 n.7.* Understanding that the law must not change from case to case or from circumstance to circumstance, a New York district court applied the Federal Circuit's claim interpretation in a separate infringement action involving the same patent. After trial, the defendant appealed. This time the Federal Circuit reversed the district court's claim interpretation. See *Tura, 112 F.3d at 1149* ("We conclude that the district court did err in its claim construction.") (emphasis added). Although this court referred to the New York district court's "error," the Federal Circuit had in fact reversed itself.

One potential trial court response to the CVI/Beta problem might be the issuance of "tentative" claim constructions as a matter of law. See *International Communications Materials, Inc. v. Ricoh Co., Ltd., 108 F.3d 316, 41 U.S.P.Q.2D (BNA) 1957 (Fed. Cir. 1997).* This response, of course, would further frustrate the parties' desire to receive a certain claim construction as early as possible.

Regardless, if the Federal Circuit's reading of the very same claim can vary from one appeal to the next, every patent litigant has an incentive to appeal every action to the Federal Circuit in hopes that the statistics will hold up and eventually

the appellate court will reverse. Even the Federal Circuit's claim interpretations as questions of law are not certain. Is this the "uniformity" outlined by the Supreme Court in Markman II?

III.

Because patent trial practitioners understand the distinct prospect of overturning trial court results on appeal, the trial arena loses some of its luster as the center stage of the dispute resolution drama. Instead the trial court becomes a ticket to the real center stage, the Court of Appeals for the Federal Circuit. Taking a cue from the Supreme Court, this court would more wisely take a functional approach to setting a standard of review for claim construction.

In Markman II, the Supreme Court noted that neither history nor precedent provided "clear answers" about the role of the jury and the factual or legal nature of claim construction. *116 S. Ct. at 1395.* Therefore, the Court pursued a functional inquiry to determine whether the judge or jury could best balance the complexities of claim construction. See id. A similar functional inquiry might best clarify the roles of the trial and appellate benches during claim interpretation.

The Supreme Court has provided some guidelines for such a functional approach. The Court counsels appellate courts to defer "when it appears that the district court is 'better positioned' than the appellate court to decide the issue in question or that probing appellate scrutiny will not contribute to the clarity of legal doctrine." *Salve Regina College v. Russell, 499 U.S. 225, 233, 113 L. Ed. 2d 190, 111 S. Ct. 1217 (1991).* At another point, the Court cautions: "The reviewing attitude that a court of appeals takes toward a district court decision should depend upon 'the respective institutional advantages of trial and appellate courts.' " *First Options of Chicago, Inc. v. Kaplan, 514 U.S. 938, 948, 131 L. Ed. 2d 985, 115 S. Ct. 1920 (1995)* (quoting *Salve Regina, 499 U.S. at 233).*

Applying this general counsel, the trial judge enjoys a potentially superior position to engage in claim interpretation. For the complex case where the claim language and specification do not summarily dispose of claim construction issues, the trial court has tools to acquire and evaluate evidence that this court lacks. Trial judges can spend hundreds of hours reading and rereading all kinds of source material, receiving tutorials on technology from leading scientists, formally questioning technical experts and testing their understanding against that of various experts, examining on site the operation of the principles of the claimed invention, and deliberating over the meaning of the claim language. If district judges are not satisfied with the proofs proffered by the parties, they are not bound to a prepared record but may compel additional presentations or even employ their own court-appointed expert.

An appellate court has none of these advantages. It cannot depart from the record of the trial proceedings. To properly marshal its resources, the appellate bench must enforce strict time and page limits in oral and written presentations.[17]

Moreover a sterile written record can never convey all the nuances and intangibles of the decisional process. Indeed a careful consideration of the institutional advantages of the district court would counsel deference. This court's categorical response that claim interpretation involves no factual assessments does not advance a functional analysis of trial and appellate roles in claim construction. As a matter of fact (so to speak), claim construction requires assessment of custom and usage in the relevant art, assessment of events during

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[17] These necessary strictures contribute to the Federal Circuit's perception of claim construction. Pressured by these necessary rules, parties before the Federal Circuit strive mightily to reduce their cases to a few issues controlled by a few passages from the specification or the prosecution history. For these reasons, the appeal process does not present a fair picture of the complex task of untangling the knot of legal and factual issues presented for trial. A seemingly simple issue of claim construction on appeal takes on an entirely different complexion in its proper context as one tiny facet of a massive corpus of litigation.

prosecution, assessment of the level of ordinary skill in the art, assessment of the understanding of skilled artisans at the time of invention—to name just a few factual components of the complex process of claim interpretation. A careful functional analysis counsels deference for district court claim interpretations.

IV.

The Supreme Court may have offered a path out of this predicament. At least three times in Markman II, as noted earlier, the Court alluded to the factual component of claim interpretation. At no point did Markman II address the appropriate standard of review. Nonetheless this court misses the opportunity to improve certainty in patent practice by giving appropriate deference to trial court claim interpretations, particularly in complex cases. If this court accords more deference to trial court interpretations in the complex cases, soon the district courts will provide the desired certainty early in the process. At that point, Markman I will fulfill its promise. Administration of patent law will move toward less costly disputes and earlier settlements.

Markman I set out to improve patent law administration by removing uncertainties from the dispute resolution process (the chief uncertainty, of course, being jury results). Inadvertently the reasoning in Markman I has postponed the point of certainty to the extreme end of the judicial process. This delay both disrupts the orderliness of trials and practitioners' hopes for more efficient and earlier claim constructions. The Supreme Court removed the jury uncertainty with its decision and, by recognizing a factual component in claim interpretation, provided a way for this court to accomplish much of its early goals. By according some deference where appropriate, this court can restore the trial court's prominence in the claim interpretation function and bring again more certainty at an earlier stage of the judicial process. Applying the Supreme Court's reasoning for habeas proceedings to claim

construction, "adoption of [a rule of appropriate deference] . . . will have the salutary effect of making the [district court's] trial on the merits the 'main event,' so to speak, rather than a 'tryout on the road' for what will later be the determinative [appeal to the Federal Circuit]." *Wainwright v. Sykes, 433 U.S. at 90.* This certainty, in turn, would stimulate more settlements and efficient decision making the promise of Markman I. With this reasoning in mind, I respectfully dissent from the claim interpretation pronouncements of the en banc opinion, concur in the judgment, and join only part IV of the en banc opinion.

NEWMAN, Circuit Judge, with whom Chief Judge MAYER joins; additional views.

As this case illustrates, perfection is elusive in the aftermath of the Federal Circuit's decision in *Markman v. Westview Instruments, Inc., 52 F.3d 967, 34 U.S.P.Q.2D (BNA) 1321 (Fed. Cir. 1995)* (en banc), aff'd, *517 U.S. 370, 116 S. Ct. 1384, 38 U.S.P.Q.2D (BNA) 1461, 134 L. Ed. 2d 577 (1996).* The expectation of greater stability in the application of patent law—thus enhancing consistency in result, reducing the cost of litigation, and indeed reducing litigation by diminishing the uncertainties of jury trials—has not been well achieved.

Most of the shortfalls between expectation and reality arise from the manner of implementation of our de novo authority for claim interpretation. I cite three principal areas. The first area relates to the treatment of certified questions. Although the district courts have extended themselves, and so-called "Markman hearings" are common, this has not been accompanied by interlocutory review of the trial judge's claim interpretation. The Federal Circuit has thus far declined all such certified questions. Indeed, the certified question issue was an early warning of the difficulties that could flow from pre-

mature claim interpretation, for it was often apparent from the petition that the claims could not be finally and correctly interpreted without evidence beyond the patent documents. The absence of extrinsic evidence, of resolution of conflicting positions, and of detailed analysis and findings by the trial judge, inhibited claim interpretation by certified question. Thus, instead of conducting the expected dispositive de novo review, we simply declined the question. The possibility of early finality to claim interpretation has not materialized, with two untoward consequences; first, the district court has had to conduct a perhaps unnecessary trial; and second, the eventual issuance of a new claim interpretation by the Federal Circuit, on appeal after final judgment, has sometimes required a second trial of the issue of infringement. None of these consequences comports with our insistence that claim interpretation is purely a matter of law, that it needs no findings at trial, and that it will be decided de novo by the Federal Circuit.

The second area of disappointed expectations has flowed from the unexpectedly creative de novo claim interpretations that the Federal Circuit has issued in a few cases. This unpredictability in administration of the law of patent claiming has added a sporting element to our bench. It has not only released appellants' imaginations on appeal, but it will surely add complexity to future trials, as lawyers attempt to guard against the judicial imagination.

A third concern, although rare in occurrence, is of great significance, for even one case wherein the Federal Circuit has deemed itself unconstrained by its own prior interpretation of the same patent removes finality and encourages relitigation of every patent. The promise of uniformity and finality, flowing from decisions of national effect, is a failed promise if we are not bound by stare decisis in our own claim interpretation.

These flaws are of serious concern, no less because they are of our own making. They are not irremediable, although remedy may require a larger vision than we possess. However, today's en banc opinion adds another encumbrance to the pro-

cedures for interpretation of claims, further inhibiting fruition of the Markman expectation. When the issues in litigation involve complex questions of science and technology, a special effort is required of the judicial process.[18] In litigation of patent disputes the nature of the evidence that is received and considered, the balance between the trial and appellate functions, and the evidentiary rules governing opinion testimony and experts, are of particular importance. Today's decision falls short in each of these areas.

Procedural and evidentiary rules should weigh toward facilitating judicial understanding of the issues and thereby reaching the correct result. Yet the Federal Circuit rules today that it will not consider factual findings of the trial court, expressly disavowing such actions by prior panels. The court continues to deny the need to make findings of disputed facts when interpreting claims: "[By] using certain extrinsic evidence that the court finds helpful and rejecting other evidence as unhelpful, and resolving disputes en route to pronouncing the meaning of claim language . . . the court is not crediting certain evidence over other evidence or making factual evidentiary findings." Maj. Op. at 7 (quoting *Markman, 52 F.3d at 981, 34 U.S.P.Q.2D (BNA) at 1331*). The court states that it neither accepts the trial judge's findings of fact, nor accepts that there are factual issues in claim interpretation. With these strictures on evidence, witnesses, and findings, it is far from clear how the Federal Circuit proposes to reach the correct claim interpretation.

By continuing the fiction that there are no facts to be found in claim interpretation, we confound rather than ease the

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[18] In 1993 the Carnegie Commission on Science, Technology, and Government wrote:

> The courts' ability to handle complex science-rich cases has recently been called into question, with widespread allegations that the judicial system is increasingly unable to manage and adjudicate science and technology issues.

Report, March 1993, p. 11.

litigation process. Without doubt, factual disputes arise and must be resolved in order to interpret the claims. Such facts are normally resolved at trial—yet we now deny ourselves the opportunity even to consider the findings of the trial court. See maj. op. at 12 (disavowing the procedure in a Federal Circuit opinion whereby the court recognized the trial court's " 'trained ability to evaluate [expert] testimony in relation to the overall structure of the patent' and the trial court's 'better position to ascertain whether an expert's proposed definition fully comports with the specification and claims' "). The court today not only rejects the opportunity to give normal appellate deference to the proceedings and findings of trial, but also rejects the opportunity to consider them at all.

In Markman the en banc court took the position that in patent cases, unlike any other area of law, a disputed question of the meaning, scope, and usage of terms of technologic art is not a question of fact, or even of law based on underlying fact, but is pure law. However, the Supreme Court has relieved us of adherence to this fiction, by its recognition of the factual component of claim interpretation. Further, the Court's affirmation that claim interpretation "is exclusively within the province of the court," *116 S. Ct. at 1387, 38 U.S.P.Q.2D (BNA) at 1463*, did not shut out the trial judge along with the jury. In declining to affirm the Federal Circuit's fact/law theory, the Court opened the door for retreat from this artificial construct. I urge us to do so, for experience shows that unforeseen and undesired consequences are flowing from its rigidity. Now that this fact/law rigor is no longer necessary for constitutional combat, let us review these consequences and accept this invitation to advance our procedures.

For example, in Markman the Federal Circuit stated that it is not a finding when one side's evidence is accepted and the other side's evidence is rejected. *52 F.3d at 981, 23 U.S.P.Q.2D (BNA) at 1331*. Since accepting one side's evidence and rejecting the other's based on an assessment of

validity would be a finding, some other criterion must be the basis for the choice. The court has never stated what this criterion could be, except that accepted evidence should be "helpful," an answer that begs the question.

A fresh view of fact and law would also ameliorate the constraints we have placed on the presentation of extrinsic evidence on the issue of claim interpretation. Patent litigation now often starts with a preliminary hearing to interpret the disputed claim terms, and often produces an early summary judgment, a path perhaps fostered by our foreclosure of the certified question. This preliminary ruling can be dispositive of the dispute, for the scope of the claim often decides whether there can be literal infringement. Thus I add to my concerns the position of the Federal Circuit, here reaffirmed, that extrinsic evidence is of strictly limited availability in claim interpretation. Such evidence should be encouraged, not restrained, if summary disposition is at hand.

The value of extrinsic evidence in claim interpretation is not surprising, because patent documents are written by and for persons in the field of the invention, not for judges. Judges not only need a larger understanding of the science or technology, but we also need help with understanding how the particular terms as used in the patent are viewed by persons in the field of the invention. As Judge Schwarzer observed:

The context in which [issues of science and technology] arise varies widely, but generally they share one characteristic. They challenge the ability of judges and juries to comprehend the issues—and the evidence—and to deal with them in informed and effective ways. As a result, they tend to complicate the litigation, increase expense and delay, and jeopardize the quality of judicial and jury decision making.

Federal Judicial Center, Reference Manual on Scientific Evidence 1 (1994). The Federal Circuit's ruling that extrinsic evidence must be restricted unless there is a facial ambiguity in the meaning of the claim is an unnecessary restraint on potentially useful evidence. See *Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579, 588, 125 L. Ed. 2d 469,*

113 S. Ct. 2786 (1993) (" 'If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert . . . may testify thereto in the form of an opinion or otherwise.' ") (quoting Fed. R. Evid. 702).

Of course the primary source of information concerning the claimed invention is the patent documents. But such documents are directed to persons knowledgeable in the field; additional evidence and expert testimony as to their meaning should be the rule, not the exception. So-called "extrinsic" evidence—the evidence of expert witnesses and of experimentation, exhibits, demonstrations, and explanation—should be treated like any other evidence, and received and given weight and value as appropriate. Our broad constraint on resort to such evidence is an unnecessary bar to enlightenment. It is also an incursion into the authority of the trial court. See *General Electric Co. v. Joiner, 139 L. Ed. 2d 508, 118 S. Ct. 512, 515 (1997)* (decision of trial court to admit or exclude expert testimony is reviewed on abuse of discretion standard).

The real issue with respect to such evidence is not the threshold question of admissibility, as this court appears to hold, but of weight, upon examination of the evidence and in conjunction with the other evidence. These too are matters for the trial judge, and when the threshold criteria of relevance and reliability are met, see Daubert, the evidence should be received and considered as appropriate to its credibility and weight. It follows that the trial court's factual findings with respect to evidence relevant to claim interpretation should be treated, on appeal, like any other finding of the trial court.

Thus it is quite discouraging to observe this en banc ruling wherein the Federal Circuit prohibits itself from considering the findings of fact made by the trial court. The majority opinion disavows this court's prior statement that "the district court's findings of scientific/technological fact were material to the issue of construction of the term." This disavowal

deprives the court, and the parties, of the accumulated progress and experience of the trial, including the findings of the trial judge, and leaves us on appeal with an expurgated record and generally inferior basis of decision. Recognizing that our appellate role is to decide whether the claims were correctly interpreted in light of all of the evidence, it is mysterious why we choose to self-censor what we will consider on appeal. It is equally obscure why this court would prohibit itself from relying on a trial court's findings, or from choosing between disputed expert positions. I strongly disagree with the majority's view of the role of extrinsic evidence, at trial and as considered on appeal.

In contrast, a return to the traditional trial/appellate relationship would achieve several important results. It would rationalize the admissibility of relevant extrinsic evidence, appellate deference would be restored instead of disavowed, and appellate review would be in accordance with the rules. The processes of both trial and appeal would benefit. This is particularly important because the evidence involved in claim interpretation, whether intrinsic or extrinsic, is often scientific or technologic. The evidence of what the invention is, how it works, what the technical words meant to persons in the field at some past time, can be of extreme complexity. When there is a dispute as to what a term of technical art or usage means or encompasses, such evidence is relevant and often is indispensable. Why would our court foreclose, or place obstacles in the path of, adducing and considering such evidence?

Surely the better view is to encourage judicial access to scientific evidence and findings based thereon. The ultimate beneficiary would be the parties, for the courts would be less restricted in the search for the correct and just result in patent cases. Thus I must, respectfully, dissent from the court's rulings on these issues.

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Fromson

PROCESS AND APPARATUS FOR CONTINUOUSLY ANODIZING ALUMINUM

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Related U.S. Patent Documents

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U.S. Cl 204/28; 204/211
Field of Search 204/28, 211, 267, 269 204/58

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ABSTRACT

Aluminum is continuously anodized using direct current in an anodizing cell having a cathode connected to the source of direct current which is succeeded by a cathodic contact cell having an anode connected to the same source of direct current. The anodizing direct current is introduced into the aluminum in the contact cell, the aluminum having an anodized oxide coating formed thereon in the anodizing cell before entering the contact cell.

11 Claims, 2 Drawing Figures

FIG. 1.

24
D.C.
12
14
10
ANODIZING CELL
18
18
22
14
20
CONTACT CELL

FIG. 2.

24
D.C.
12
14
10
ANODIZING CELL
18
16
16
14
20
CONTACT CELL
22
22
24'
D.C.
14
10'
18'
16
ANODIZING OR OTHER ELECTROLYTIC TREATMENT CELL

PROCESS AND APPARATUS FOR CONTINUOUSLY ANODIZING ALUMINUM

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in *italics* indicates the additions made by reissue.

BACKGROUND

This invention relates to process and apparatus for continuously anodizing aluminum. The term aluminum is used herein to include aluminum base alloys which, like pure aluminum, can be electrolytically anodized to form oxide coatings. More particularly, this invention relates to a technique for continuously anodizing coils or lengths of aluminum, such as aluminum sheets, strips, wire, rods, shapes and the like (hereinafter collectively referred to as aluminum web), by introducing direct current in a cathodic contact cell into an aluminum web passing there through having an oxide coating thereon formed in an anodizing cell which precedes the contact cell. The direct current is picked up in the cathodic cell by the already anodized web and is transferred therealong countercurrent to the direction of movement of the web to the anodizing cell in which the oxide coating is formed.

Aluminum and aluminum base alloys in sheet, strip and wire form have been continuously anodized by a number of techniques for many years. Such anodized products are used for electrical and decorative purposes, in the manufacture of household appliances, automotive trim, building materials, farm equipment, furniture, sporting goods, cans, container closures, lithographic plates, transformers, and in many other market and product areas.

Two basic techniques are used to introduce current into a moving aluminum web. The first involves the use of a contact roll or bar and the second is an electrochemical technique utilizing a cathodic contact cell.

The contact roll or bar technique suffers from many deficiencies. For example, the aluminum web must be dry to avoid electrolysis which, if it occurs, dissolves the contact roller or bar anodically leaving pits in the surface thereof. [Anoter] *Another* problem is [arching] *arcing* between the two surfaces as they become separated which is brought about by the presence of edge burrs or slivers of aluminum on the web surface itself. Arcing causes pitting of the aluminum as well as pitting and oxidation of the contact member itself.

When using the cathodic contact cell technique, one of the limits on how much current can be introduced into the web is the fact that all of the current has to be introduced into a cross-sectional area of the moving web. This causes a surge of current into the unanodized web which is unprotected by an oxide coating. This tends to cause burning and results in the formation of unsound oxide coatings. Up to now the problem of arcing in the use of a solid contact member and the problem of burning due to a surge of current in the contact cell technique have been accepted as inherent limitations in the continuous anodizing of aluminum for the reason that all of the current for the anodizing operation has to be picked up by the moving web in one pass. The reason advanced for this is the fact that the anodic oxide coating formed in the anodizing operation is an electrical insulator.

The present invention now makes it possible to introduce anodizing current into more than one cross-section of the moving aluminum web and imparts to the moving web the means to avoid burning caused by a surge of current into the moving web as it enters the anodizing cell.

SUMMARY

In its broadest terms, the present invention provides an improvement in a process for continuously electrolytically anodizing aluminum web using direct current. The direct anodizing current is introduced into the aluminum web in a cathodic contact cell, the web having an anodized oxide coat-

ing formed thereon before entering the contact cell by the action of the direct current introduced in the contact cell. In a preferred embodiment, anodizing direct current from two or more sources is introduced into the aluminum web in a cathodic contact cell, the strip having an anodized oxide coating formed thereon before entering the contact cell through the action of the direct current introduced in the contact cell itself.

Stated differently, the process of the invention for continuously electrolytically anodizing aluminum web comprises continuously passing an aluminum web through an anodizing cell having a cathode connected to a source of direct current, continuously passing the aluminum web from the anodizing cell into a cathodic contact cell having an anode connected to the same source of direct current, and introducing anodizing direct current into the aluminum strip in the contact cell, the aluminum web having an anodized oxide coating formed thereon in the anodizing cell before entering the contact cell. Preferably, the contact cell has a second anode connected to a second source of direct current and the aluminum web is continuously passed from the contact cell into a second anodizing or other electrolytic treatment cell having a cathode connected to the second source of direct current.

DESCRIPTION OF THE DRAWING

The present invention will be more fully understood from the following description taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a schematic flow diagram illustrating the features of the invention in its most basic form; and

FIG. 2 is a schematic flow diagram illustrating a preferred embodiment of apparatus for carrying out the process of the invention in a preferred manner.

DESCRIPTION

The present invention makes it possible to introduce anodizing current into a moving aluminum web into more than one cross-section thereof and into a moving web that already has at least one protective oxide layer formed thereon. This can be accomplished by using a cathodic contact cell, in which the aluminum web is cathodic, between two anodizing cells in which the aluminum strip is anodic, or by utilizing a multiplicity of electrolytic cells in which the aluminum web is alternatively negative or positive. When utilizing the preferred embodiment of the cathodic contact cell between two anodizing cells, the current introduced into the contact cell will travel in both directions thus effectively doubling the current carrying capacity of the moving aluminum web.

Referring now to the drawing and in particular to FIG. 1, the process and apparatus for continuously [for] electrolytically anodizing aluminum web 12 includes an anodizing cell indicated generally by reference numeral 10 followed by a contact cell indicated generally by reference numeral 20. Each cell includes a suitable tank member 16 for containing an electrolyte 14. The anodizing cell 10 has a cathode 18 therein connected to a source of direct current 24. The contact cell 20 has an anode 22 therein which is connected to the same source of direct current 24. The aluminum web 12 continually passes through the anodizing cell 10 followed by the contact cell 20 with the aid of conventional guide rollers positioned as shown in FIG. 1.

The anodizing direct [curret] *current* is introduced into the web 12 in the contact cell 20. The web 12 has an anodized oxide coating formed thereon in the anodizing cell 10 before entering the contact cell 20 by the action of the direct current introduced into the web 12 in the contact cell 20.

FIG. 2 illustrates a preferred embodiment wherein a second anodizing or other electrolytic treatment cell follows the contact cell 20. The second cell 10' contains a cathode 18' which is connected to a second source of direct current 24'. The con-

tact cell 20 contains a second anode 22' which is connected to the same second source of direct current 24'. Thus, by utilizing the preferred embodiment illustrated in FIG. 2 with a contact cell 20 between two anodizing cells 10 and 10', the direct anodizing current introduced into the contact cell 20 from the two separate sources of direct current 24 and 24', travels in both directions thus effectively doubling the current carrying capacity of the moving aluminum web 12. Stated differently, anodizing current is introduced into the web 12 in contact cell 20 from current source 24 which flows in a direction opposite to the direction of movement of the web 12 into the preceding anodizing cell 10 wherein a portion of the desired anodized porous oxide coating is formed. The anodizing operation is completed in anodizing cell 10' by anodizing current from source 24' picked up by the strip 12 and contact cell 20 which is transmitted therealong to the anodizing cell 10'. The web 12 exits from anodizing cell 10' with the desired thickness of porous oxide coating formed thereon.

Instead of a second anodizing treatment in cell 20', which reinforces and adds to the oxide coating formed in cell 20, a further electrolytic treatment wherein the web 12 is positive can be carried out in cell 20'. For example, an electrophoresis operation can be carried out in the embodiment of FIG. 2 in cell 20 whereby resin or lacquer particles are deposited in or on the pores of the oxide coating formed in cell 20.

With respect to the embodiment shown in FIG. 1, the invention can be carried out by passing aluminum web 12 through at least two successive pairs of anodizing cell 10 followed by a contact cell 20.

As is well known in the art, the aluminum web 12 can be cleaned, de-greased or otherwise pretreated using conventional techniques before it reaches the anodizing section and after leaving the anodizing section it can be sealed, dyed or otherwise post-treated using known techniques. The web 12 is passed through the anodizing operation of the invention using conventional winding and feeding equipment.

The present invention will be more fully understood from the following examples which are not intended to limit or otherwise restrict the invention in any way. In the examples 4 × 8 inch sheets were employed. In all of the examples both sides of the aluminum sheets were anodized and the electrolyte concentration was 230 grams per liter of aqueous sulfuric acid.

EXAMPLE 1

Aluminum samples were anodized in the sulfuric acid electrolyte at constant electrolyte concentration and temperatures. DC voltage breakdown values were determined and are summarized in Table 1 below:

TABLE 1

CURRENT (in amps)	Time ANODIC (sec.)	Time CATHODIC (sec.)	VOLTAGE BREAKDOWN (volts DC)
25	60	—	380
25	60	60	380
25	60	30	380
25	30	—	290
25	30	30	290
25	30	15	290
20	20	20	220

The results of this Example indicate that reversing the polarity, or passing current through an oxide coating, has no detrimental or adverse effect on the anodized oxide coating. This is indicated by the DC voltage breakdown values which are identical for samples which were subjected to cathodic time and for samples which were not so subjected to cathodic time.

EXAMPLE 2

Triple sets of aluminum samples were prepared and all were anodized for the same period of time and at the same current

density. Set number 1 was anodized only. Set number 2 was anodized and allowed to sit in the electrolyte while the polarity was reversed (samples Cathodic). Set number 3 was anodized and allowed to sit in the anodizing electrolyte without applying any current. For all three sets the [andizing] *anodizing* time, the time the polarity was reversed and the time the anodized samples were allowed to sit in the electrolyte was the same.

All of the samples were sealed in boiling water. The weight of the oxide coating formed were determined by first weighing the sample and then stripping off the oxide coating by soaking in a hot chromic-phosphoric acid solution and thereafter re-weighing the sample. The difference in weight divided by the total area of the sample gives the milligrams per square inch of oxide coating on the original sample. The results are summarized in Table 2.

This example illustrates that there is very little difference in the weight of the oxide coating between samples where the polarity was reversed and samples where the anodized samples were allowed to soak in the anodizing electrolyte. This indicates that the loss in oxide weight is due primarily to solvent action of the electrolyte and is not attributable to the passage of current through the coating when the polarity is reversed and the samples are cathodic. In evaluating the data of Table 2 it should be pointed out that the solvent action of the anodizing electrolyte is increased as the temperature increases which accounts for the greater loss in oxide weight at the tests run at higher temperatures.

EXAMPLE 3

Aluminum samples were anodized following three steps:

1. The sample was anodized at 40° C. at a current density of 50 a/ft^2 for a specific length of time.

2. With the current density remaining at 50 a/ft^2, the polarity was reversed making the sample cathodic while varying in temperature and time.

TABLE 2

TIME (sec)	CURRENT DENSITY (a/ft^2)	ACTUAL CURRENT (amps)	VOLTAGE (volts)	"Reversed" VOLTAGE (volts)	TEMP. ° C)	WEIGHT OF SET 1 (mg/in^2)	WEIGHT OF SET 2 (mg/in^2)	WEIGHT OF SET 3 (mg/in^2)	% WEIGHT LOSS BETWEEN SET 1 and 2
150	40	15.5	16	2	30	5.57	5.45	5.21	2
150	40	15.5	13	2	40	5.09	4.62	4.67	9
150	40	15.5	10	2	50	4.56	2.94	3.09	33

TABLE 3

TIME STEP 1 (sec)	VOLTAGE STEP 1 (volts)	TIME STEP 2 (sec)	VOLTAGE STEP 2 (volts)	TEMP STEP 2 (° C)	TIME STEP 3 (sec)	VOLTAGE STEP 3 (volts)	TIME STEP 1 & 2(sec)	SAMPLE COATING WEIGHT (mg/in^2)	CONTROL COATING WEIGHT (mg/in^2)	% WEIGHT LOSS OF SAMPLE
54	13.5	48	2	60	66	13	120	4.488	4.946	9.26
54	13.0	48	2	50	66	13	120	4.496	4.804	6.41
54	13.0	48	2	40	66	13	120	4.867	5.013	2.90
54	13.0	48	2	40	66	13	120	4.788	4.875	1.78
108	13.5	96	4	60	132	13	240	7.229	9.229	21.67
108	13.5	96	2	50	132	13	240	8.179	9.329	12.32
108	13.0	96	2	40	132	13	240	8.558	2.279	7.77

3. The aluminum sample was again anodized at 40° C. at a current density of 50 a/ft^2 for a specific length of time.

Control samples were anodized at 40° C. at a current density of 50 a/ft^2 for a period of time equalling the total time in steps 1 and 3. Step 2 was eliminated.

All samples in this example were sealed in hot water and the oxide coating weights were determined as described in Example 2. The data are summarized in Tables 3 and 4 below:

TABLE 4

TOTAL AMPERE MIN	TEMP STEP 2 (° C)	WEIGHT OF SAMPLE (mg/in^2)	WEIGHT OF CONTROL (mg/in^2)	% WEIGHT LOSS OF SAMPLE vs. CONTROL	
100	60	4.488	4.946	9.26	
100	50	4.496	4.804	6.41	
100	40	4.788	4.875	1.78	} 2.34
100	40	4.867	5.013	2.90	
200	60	7.229	9.229	21.67	
200	50	8.179	9.329	12.32	
200	40	8.558	9.279	7.77	
320	60	8.304	13.942	40.43	
320	50	10.729	14.025	23.50	
320	40	12.817	13.984	8.34	

NOTE:
Ampere min = time anodized
X current density
C.D. = 50 a/ft^2
Anodizing Temperature = 40° C

It is known that anodic oxide requires a forming voltage of somewhere between 12 and 13 volts (cf. Finishing Of Aluminum, Wernick and Pinner). The foregoing Examples demonstrate that when the polarity is reversed and the anodized aluminum samples are made the negative or cathodic pole of the cell, the anodized samples exhibit an

unusual phenomenon and at the same current density used to anodize, the voltage drops to between 1 and 2 volts. Only minor heat is generated by resistance and there is practically no weight loss as demonstrated herein. This unique property makes it possible to continue to introduce or feed current into the aluminum web at portions where the anodic oxide coating has already been formed. By using this technique, it now becomes possible to continuously DC anodize aluminum webs without the limitations imposed by the contact roll method or the standard contact cell method where all of the current is introduced in one pass through a single cross-section of the web. In addition, by utilizing the preferred embodiment illustrated in FIG. 2, the invention makes it possible to minimize the problem of burning by enabling the contact cell to feed anodizing direct current into the web 12 after the oxide coating has been formed.

Because the aluminum web entering a cathodic contact cell according to the invention already has an anodized oxide coating formed thereon before entering the cell, it is now uniquely possible to use as the anode for the contact cell, a platable metal such as copper, nickel, zinc and the like. In this manner, direct current introduced into the aluminum web in the contact cell for forming an anodized oxide coating thereon before the web [enteres] *enters* the cell, can also be used to deposit platable metals from the anode in or on the anodized oxide coating formed on the aluminum web before it enters the contact cell. The oxide coating is porous in nature and provides an excellent surface for adhesion with metals plated onto the oxide coating in the contact cell. In effect, this embodiment utilizes direct current from one source for carrying out two operations, viz, forming an oxide coating on the aluminum web before it enters the contact cell and depositing platable metals on the preformed oxide coating while the aluminum web passes through the contact cell.

Because of the plated metal surface on an aluminum web leaving a contact cell according to the invention utilizing an anode made of a platable metal, it then becomes possible to

use conventional continuous electroplating techniques to thereafter deposit one or more electroplated metal layers on the aluminum web, for example even using conventional contact drums and the like.

What is claimed is:

[1. In a process for continuously electrolytically anodizing aluminum, the improvement which comprises introducing anodizing direct current into said aluminum in a cathodic contact cell having therein an anode connected to said source of direct current, said aluminum having an anodized oxide coating formed thereon before entering said cell through the action of the direct current introduced in the contact cell itself.]

2. In a process for continuously electrolytically anodizing aluminum, the improvement which comprises introducing anodizing direct current from two or more sources in a cathodic contact cell having therein anodes connected to said sources of direct current, the aluminum having an anodized oxide coating formed thereon before entering said cell through the action of the direct current introduced in the contact cell itself.

[3. Process for continuously electrolytically anodizing aluminum web which comprises continuously passing said web through an anodizing cell having therein a cathode connected to a source of direct current, continuously passing said web from said anodizing cell into a cathodic contact cell having therein an anode connected to said source of direct current, and introducing anodizing direct current into said web in said contact cell, said web having an anodized oxide coating formed thereon in said anodizing cell before entering said contact cell through the action of the direct current introduced in the contact cell itself.]

[4. Process of claim 3 wherein said contact cell has a second anode connected to a second source of direct current and said web is continuously passed from said contact cell into a

second cell having a cathode therein connected to said second source of direct current.]

[5. Process of claim 4 wherein said second cell is an anodizing cell.]

[6. Process of claim 4 wherein said second cell is a further electrolytic treatment cell.]

[7. Process of claim 3 wherein said aluminum strip is passed through at least two successive pairs of said anodizing cell followed by said contact cell.]

[8. Apparatus for continuously electrolytically anodizing aluminum web which comprises anodizing cell means containing a cathode connected to a source of direct current, cathodic contact cell means containing an anode connected to said source of direct current, and means for continuously passing said aluminum web first through said anodizing cell means and then through said contact cell means, the anodizing direct current entering said web in said contact cell means with an anodized oxide coating formed thereon through the action of the direct current introduced in the contact cell itself.]

[9. Apparatus of claim 8 wherein said contact cell means contains a second anode connected to a second source of direct current and a second cell means are provided containing a cathode connected to said second source of direct current, said means for passing being adapted to continuously pass said web through said second anodizing cell means after passing through said contact cell means.]

[10. Apparatus of claim 9 wherein said second cell means is an anodizing cell means.]

11. In a process for continuously electrolytically anodizing a moving aluminum web using the cathodic contact cell technique, the improvement which comprises introducing anodizing direct current from at least two direct current sources into said moving aluminum web into at least two cross-sections

thereof, portion of the anodizing being carried out before the aluminum web enters the contact cell.

12. Process of claim 11 wherein the anodizing current is introduced by passing said moving aluminum web through at least two successive pairs of an anodizing cell followed by a contact cell.

13. Process of claim 11 wherein the anodizing current is introduced into said moving aluminum web by using a contact cell between two anodizing cells whereby anodizing current introduced from a first source of direct current into the first cross-section of said web flows in a direction opposite to the direction of movement of said web and anodizing current introduced from a second source of direct current into the second cross-section of the web flows in the direction of movement of said web.

14. Process for continuously forming a porous anodic oxide coating on aluminum which comprises:

(i) passing aluminum through a cathodic contact cell, said aluminum having a portion of the thickness of said porous anodic oxide coating already formed thereon before entering said contact cell through the action of anodizing direct current from a first source of direct current introduced into said contact cell; and

(ii) further anodizing the already anodized aluminum to form the remaining portion of the thickness of the porous anodic oxide coating by introducing anodizing direct current from a second source of direct current into said already anodized aluminum in said contact cell.

15. Process for continuously forming a porous anodic oxide coating on an aluminum web which comprises:

(i) passing said web through a first anodizing cell having therein a cathode connected to a first source of direct current;

(ii) passing said web from said first anodizing cell into a cathodic contact cell having therein an anode connected to said first source of direct current and a second anode connected to a second source of direct current;

(iii) passing said web from said contact cell into a second anodizing cell having a cathode therein connected to said second source of direct current; and

(iv) introducing anodizing direct current from said sources into said web in said contact cell thereby forming a portion of the thickness of the porous oxide coating in said first cell and the remaining portion in said second anodizing cell.

16. Process of claim 15 wherein said second anodizing cell is replaced by a further electrolytic treatment cell.

17. Process for continuously forming a porous anodic oxide coating on an aluminum web which comprises:

(i) passing said web through a first anodizing cell having therein a cathode connected to a first source of direct current;

(ii) passing said web from said first anodizing cell into a first cathodic contact cell having therein an anode connected to said first source of direct current;

(iii) passing said web from said first contact cell into a second anodizing cell having therein a cathode connected to a second source of direct current; and

(iv) passing said web from said second anodizing cell into a second cathodic contact cell having therein an anode connected to said second source of direct current.

18. Apparatus for continuously forming a porous anodic oxide coating on an aluminum web which comprises first anodizing cell means containing a cathode connected to a first source of direct current, cathodic contact cell means containing a first anode connected to said first source of direct current and a second anode connected to a second source of direct current, second anodizing cell means containing a cathode connected to said second source of direct current means for continuously passing said aluminum web through said first anodizing cell means, then through said contact cell means and lastly through said second anodizing cell means, the anodizing direct current from said sources entering said web in said contact cell means.

19. Apparatus of claim 18 wherein said second anodizing cell means is replaced by a further electrolytic treatment cell means.

20. Apparatus for continuously forming a porous anodic oxide coating on an aluminum web which comprises first anodizing cell means containing a cathode connected to a first source of direct current, first cathodic contact cell means containing an anode connected to said first source of direct current; second anodizing cell means containing a cathode connected to a second source of direct current, second contact cell means containing an anode connected to said second source of direct current, and means for passing said web successively through said first anodizing cell means, said first contact cell means, said second anodizing cell means, and said second contact cell means.

* * * * * * *

[Plaintiff's Exhibit 46]

Outline, Anitec Printing Plate R & D Review,
Dr. Carl Ernst
February 7 & 8, 1991

I) *Current Product Technology*

A) *Substrate Manufacture*

B) *Additive Plates*

1) Lithographic Diazoniums

2) Additive Developers/Finishers

3) Product Line

a) Wipe-On (NXE, NSR)
b) Conventional Pre-Sensitized (A-109)
c) Projection (GC-103)
d) Developers/Finishers (N, Super Image Seal)

C) *Subtractive Plates*

1) Diazonium/Polymer

2) Photopolymer

3) Diazonium/Photopolymer

4) Subtractive Developers/Finishers

5) Product Line

a) Conventional (C-300, P-200, M-100, N-225, Duplex)
b) Projection (Presto)
c) Developers/Finishers (Series 200 Developer, Finisher, 2-in-1 Developer/Gum)

D) *Positive Plates*

1) Napthalene Quinone Diazide (NQD)/Polymer

2) Conventional

3) Gemini

4) Product Line (Horsell/Freundorfer)

II) *R & D Project Review*

A) 1st Generation Subtractive Projection Plate (Presto)

B) Extended Shelf-Life Conventional Subtractive Plates

C) Reactive Pigment Dispersion—Increased Length of Run

D) Overlay Color Proofing Film System

E) Environmental Additive Developer

F) Subtractive Develper Replenisher

G) Plate Cleaners

H) Process Standardization Task Force

I) New Projects

J) Basic and Applied Research

III) *Worldwide Negative Plate Technology*

A) Anitec Printing Plates/Horsell-Freundorfer

B) Competitors

I), A) *Substrate Preparation*

Mechanically and electrochemically grained, electrochemically anodized, silicated aluminum.

1) *Incoming Aluminum*

— Alloy
— Temper
— Surface

2) *Process Steps*

a) *Degreasing*

— Hot (160°F) aqeuous surfactant solution
— Removal of oils and surface contaminants from rolling process

b) *Mechanical Graining*

— Nylon brushes/sand-pumice slurry
— "Coarse" directional grain
— Removes natural oxide layer and minor surface defects from aluminum

c) *Electrochemical Graining*

— Hydrochloric/phosphoric acid electrolyte, single phase A.C. current, 85°F.
— Generation of "fine" grain superimposed on mechanical grain. Some "smoothing" of the coarse mechanical grain.
— Controlled "pitting" or etching process.

d) *Desmut*

— Ambient temperature nitric acid/ammonium bifluoride
— Removal of contaminants generated by electrochemical graiing, brightening of the substrate
— Some "smoothing" of the grain

e) *Phosphoric Anodizing*

- — Phosphoric acid electrolyte/D.C. current, 123°F
- — "Thin" layer of phosphated anodizing which rises to the substrate surface
- — Controls adhesion of exposed coating, enhances release of unexposed coating; produces length of run and shelf life of product.

f) *Contact Tank*

- — Sulfuric acid/D.C. current, 80°F
- — Completes electrical circuit to the phosphoric and sulfuric anodizing tanks
- — Some further cleaning of the substrate

g) *Sulfuric Anodizing*

- — Sulfuric acid/D.C. current, 70°F
- — "Thick" layer of sulfated anodizing *under* "thin" phosphated anodizing
- — Provides durability to the substrate

h) *Silication (Post Anodic Treatment, P.A.T.)*

- — Water soluble glass of a specific SiO_2/Na_2 0 ratio applied at 160°F
- — Seals the anodic layer to prevent further oxidation
- — Promotes adhesion of exposed coatings, in particular diazoniums.

A lithographic printing plate is a system comprising the substrate and light sensitive coatings. To produce a world class product, both the substrate and the coatings must be designed to compliment one another. They can not be regarded as separate components.

PROCESS CONDITIONS—ANITEC PRINTING PLATES

Line 5

Speed 30 Feet/Min.

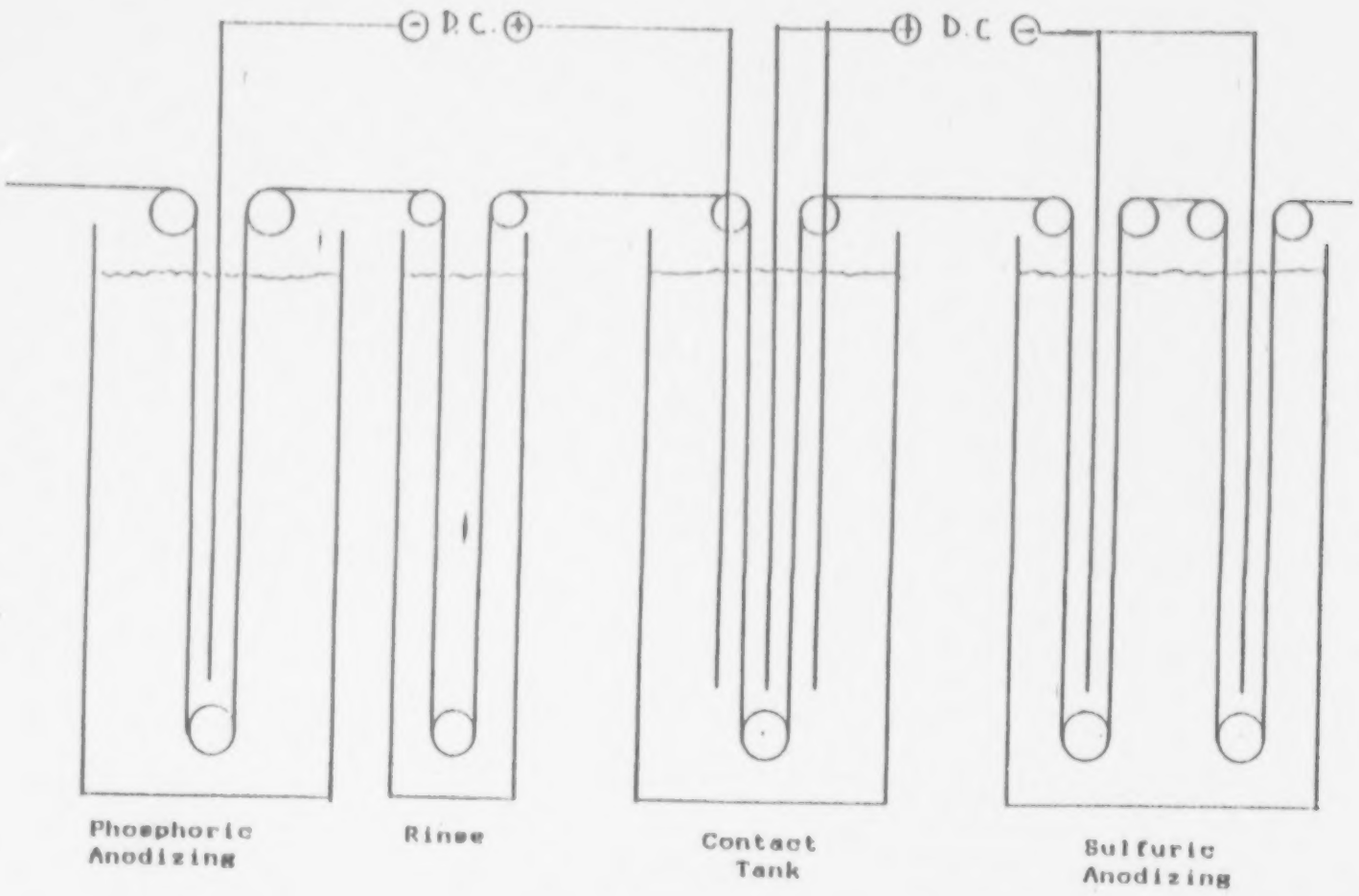
Products Craftsman 300. Performer 200.
Manuscript 100, Newsworthy 225. Presto

Process	Components	Concentration	Temperature (°C)	Dwell (Secs.)
Degressing	Diversav-Wyandotte DW-19 Non-Etch Aluminum Cleaner	7.0 g/l	71	72.5
Rinse		Filtered City Water		
Slurry Grain	1.1 7-0 Quartz Sand/Pumice: Nylon Brushes	35% Solids (V/V) Slurry	Ambient	24
Rinse		Filtered City Water		
Electrochemical Grain 1	20°Be (31.6%) HCl 85% H_3PO_4	14.0 g/l 2.15 g/l	29	28
No Rinse				
Electrochemical Grain 2	20°Be (31.6%) HCl 85% H_3PO_4	14.0 g/l 2.15 g/l	29	28
Rinse		Filtered City Water		

Desmut (Cleaning)	42°Be (67.2%) HNO_3 $NH_4 HF_2$	41.9 g/l 3.5 g/l	Ambient	28.3
	Rinse ↓	Filtered City Water		
Phosphoric Anodizing	85% H_3PO_4	345.7 g/l	51.7	30
	Rinse ↓	Filtered City Water		
Anodizing Cathode	66°Be (93.2%) H_2SO_4	264.8 g/l	26.7	51.7
	No Rinse ↓			
Sulfuric Anodizing	66°Be (93.2%) H_2SO_4	226.3 g/l	26.7	61.7
	Rinse ↓	Filtered City Water		
Post Anodic Treatment	Silicate (10.6% Na_2O 26.5% S_7O_2)	32 g/l	71	29.2
	Rinse ↓	Filtered City Water. Dry		

To Coater

Anodizing Section



[Plaintiff's Exhibit 64]

Research Meeting Minutes
September 25, 1990

Present: Paul Perron, Tom Gillich, Maria Sypek, Lisa Johnson, Mark Erdeski, Paul Giusto.

Copies: Carl Mappin, Ron Rezzani.

Paul P: Line 5 is running fairly well with consistent speeds similar to line 3. Lines 3 and 5 have similar anodizing which is somewhat different than line 4. Line 5 closely duplicates line 3. Cosmetics are also at a good level.

I am the sponsor of the Process Standardization Task Force, which will be responsible for standardizing all lines. This is most likely a long term effort, perhaps 2+ years.

Line 3 is approaching Craftsman 300 quality.

The patent pending will become 2 separate patents, 1 process related, and 1 methods related.

The meetings with the research staff went satisfactorily. If there are further issues that concern the staff Maria and I should be told. We have Carl's full support.

Maria: Projection Speed plate trial report: Trial of standard product went well. The optimized formulation with the Kottmair diazo was not successful; however. The coating weights were unacceptable to produce the color. They aged well, with a better visible image even at the lower coating weight. It did not look as good as the standard coating on press.

I tried to determine why the optimized formulation did not work well during the coating trial. Although

the coating weight was low, the solids of the mix were high. Since the color was also high, there must have been a high level of chip in the mix. Through susequent testing, it was determined that the coating is thermally sesitive. It appears to statify at cooler temperatures. Solids will be higher or lower, depending upon how the mix is sampled. If it is mixed for four hours, or is brought back to room temperature, it appears to come back to its original state. The instability cannot be simulated in the lab refrigerator. All stock solutions should be stored at room temperature, and stirred for at least 2 hours before being used.

Paul P: The chip may be the problem; it is thick upon standing, but thin upon stirring. Also, there is no barium sulfate filler settling out as is seen with the red chip.

Maria: In project 104-17, the concentration of the diazo and color change system were varied in the projection speed

* * *

Mark: In project 105-50 the new C7 formulation with 2x DSO-19 and no Sandoray 1000 was tested. This variation aged as well as the standard product, and with lab coatings the visible image was significantly improved. The improvement in VI with the production plates was not as great; however.

Paul P: Effective Monday all C7 products will have 2x DSO-19 and no Sandoray.

Mark: Aging of line 4 vs. line 5 205C7 material was described in project 105-55. Line 5 plates aged slightly better than line 4 plates, in all accelerated aging series, had a slightly better VI, and had sig-

nificantly less bkg. staining in the 60C/80% R.H. test.

Paul P: The differences between the lines with respect to anodizing was described, the diagrams on the attached sheets were presented.

The phosphoric anodizing layer is very thin, but improves the release and adhesion of the diazo at the same time. Although the phosphoric anodizing is done first, anodizing always takes place at the interface, so when the web is later sulfuric acid anodized, a thick layer of sulfuric anodizing is produced under the phosphoric anodizing.

Paul G: In project 108-2 and 4, new lots of TG-13-43 were qualified, no decomposition of the TG-13 tar is yet evident.

In Project 108-2, ICI's samples of high purity Metanil Yellow were tested. There is no advantage to using these materials over the current Atlantic M.Y. now being used (the limited solubility of the free acid sample had adverse effects on the aging of the plate).

In project 108-4, the new lot of Penn reactive chip #RD22651-79 (9700 in PM was used instead of pure 9700) was tested and determine to behave similarly to the previous lot of reactive chip in C11G.

TG-3'-PJS#2889092 was approved for used in production as a wash and base in project 108-6.

In project 108-1, various diazo only plates with added M.Y, Kodak dye, and p-Toluenesulfonic Acid were tested. Overall; addition of the M.Y, the Kodak dye, and p-TSA did not result in dramatic improvements in aging of the diazo only plates and also decreased the speed of the plates. Differences and improvements may be more obvious if the

plates are tested at 70C. The results are not as promising as Mark's results in project 105-33 because of the different ratios of diazo to M.Y. in the C11G (Paul) and the C7 (Mark) products.

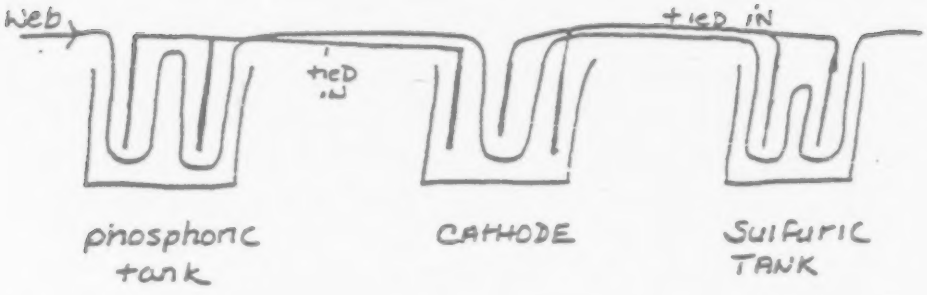
In project 108-3, 5 the continuation of the Diazo/ Metanil Yellow study was described. The Kottmair diazo ehibited similar behavior as TG-3 when M.Y. was added to it, although the absorbance increase was much less. TG-84 exhibited a dual peak spectra, showing the diazo peak and the M.Y. peak separately. The low lambda max of this diazo is a possible explanation. DSO-19-M.Y. behaved similarly to Kottmair (high initial absorbance, with little change in absorbance for the M.Y. salt). TG-3-Kodak dye salt was similar to TG-3-M.Y. salt, and TG-3-Mesitylenesulfonate salt was similar to standard TG-3. Further testing of diazo only plates and C11 plates with similar additions will be done

Paul P: The next meeting will be on October 23, 1990.

Anodizing: 9-25-90

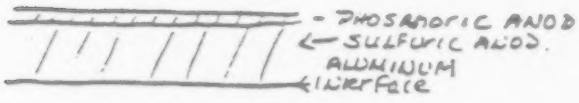
Lines # 1, 3 & 5 – Set-Up

1 = electrodes

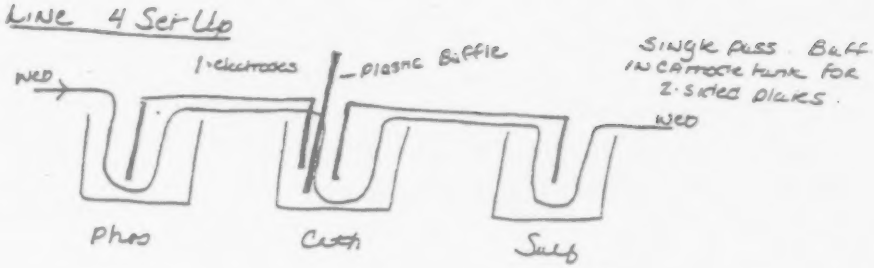


phosphoric anodizing—improves the release of unexposed diazo, improves adhesion of exposed diazo, impreoves overall grain structure. It's a very thin layer at surface—difficult to measure. The bulk of anodic layer is sulfuric anodizing. Temp must be hot or ph[ILLEGIBLE] 123°C cooler temp or sulfuric anodizing occurs at the aluminum interface lower the T (sulfuric anod), the harder the anodic layer.

i.e.



Line # 4 Set-Up



Double sets in Lines 1, 3 & 5 because these lines were designed to run faster. When they're run at same speed as Line 4, anodizing is greater because Line 4 has single pass only. There's also a bubble in cathode tank for when 2-sided plates are run so that both sides will have same degree of anodizing. Result is reduction in anodic layer on 1 side (Line 4).

Lesser phosph. anodizing on Line 4 corresponds to lesser shelf life on Line 4 product (in comparison to Lines 1, 3, & 5.

Definition of "anodize" from Webster's
Third New International Dictionary
of The English Language
(p. 88)

anodize *or* anodise . . . [*anode* + *-ize*]: to subject (a metal) to electrolytic action by making (it) the anode of a cell before coating with a protective or decorative film

[Plaintiff's Exhibit 173]

Consommation et Corporations Canada
Consumer and Corporate Affairs Canada

Bureau des brevets
Patent Office
Ottawa, Canada
K1A 0C9

1,309,374
528,697
1987/02/02
1992/10/27
204-9
INTL. CL. C25B-11/04; C25B-11/08; 301D-39/20
CANADIAN PATENT

Porous Anodic Aluminium Oxide Films

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Alcan International Limited, Canada

(GB) U.K. 8602582 1986/02/93

17 Claims

NO DRAWING

POROUS ANODIC ALUMINIUM OXIDE FILMS

This invention relates to porous anodic aluminium oxide films of substantial area and thickness, and to methods of making such films by anodizing aluminium metal substrates in phosphoric acid-based electrolyte. The invention includes the films when attached to a metal substrate, but is particularly concerned with the films after separation from the metal substrate on which they were formed.

Our European Patent Specification 178831 describes porous anodic aluminium oxide films having a particular structure, and methods of separating such films from aluminium metal substrates by a voltage reduction technique. Such films, together with other anodic oxide films of different structure, are useful as filters. For this purpose, it is important that the pores extending through the films should not be reduced or closed in use, for example as a result of swelling of the anodic oxide material.

When an aluminium metal substrate is anodized in an electrolyte, the resulting anodic oxide film contains a significant proportion of anions derived from the elctrolyte. For example, when the electrolyte is based on phosphoric acid, the film may typically contain 2 to 3% by weight of combined phosphorus. It is well known that the presence of combined phosphorus in the film inhibits hydration and swelling of the anodic oxide. Hence, where films are to be used, e.g. as filters, in circumstances where pore size is important, there is a strong preference to form them by anodizing in phosphoric acid.

Phosphoric acid anodizing is widely practiced on a commercial scale. For example, G.B. 1532112 describes a continuous phosphoric acid anodizing process to provide a base for subsequently applied adhesive. Large areas of aluminium are phosphoric acid anodized to provide plates for lithography. But in these cases, the anodic oxide films produced are thin, always less than about 3 microns and often well below 1 micron, and made by anodizing at low voltage.

Thicker phosphoric acid anodized films have been made, but only on a laboratory scale. R.C.Spooner (Plating, 1971, 5B, pages 449 to 457) made films up to 7 microns thick, but reported that "the maximum film thickness for phosphoric acid films is less than the normal minimum thickness of interest. . . .". G.E.Thompson et al (Transactions of the Institute of Metal Finishing, 1975. 53, pages 97 to 102) made films 25 microns thick on 3cm^2 electrodes.

High voltage anodizing of aluminium is carried out on a large scale in the production of hard anodic films having good wear resistance. This is carried out in 10 to 20% sulphuric acid at temperatures around 0°C to give rise to films having a minimum hardness of 400 to 500 VPN associated with good wear and abrasion resistance. Good control of operating conditions, including electrolyte temperature, are required for this purpose, but the control problems have been solved for production on a commercial scale.

Phosphoric acid anodizing gives rise to soft anodic films having low wear resistance. This arises because alumina is much more soluble in phosphoric acid than in sulphuric acid, so that anodic oxide film formation in phosphoric acid is always accompanied to a significant extent by film dissolution. The production of thick phosphoric acid anodized films of substantial area requires much more careful control of anodizing conditions than does corresponding sulphuric acid anodizing. Hitherto, thick phosphoric acid anodized films have never been of more than laboratory interest. As a result of our (unpublished) work on the use of such films as filters, there is now a need to make such films on a substantial scale. It is an object of this invention to fulfil that need.

In one aspect, the invention provides a porous anodic aluminium oxide film having a major face with an area of at least 50 cm^2 and a thickness of at least 5 μm, the film material containing phosphorus derived from the anodizing electrolyte, wherein the film is separate from a metal substrate on which it was formed.

In another aspect, the invention provides a porous anodic aluminium oxide film having a major face with an area of at least 50 cm^2, the pores being spaced from 0.15 to 0.5 µm apart on the face and the film material containing phosphorus derived from the anodizing electrolyte, wherein the film is separate from the metal substrate on which it was formed. Usually the film is at least 1 µm or micron, prefearbly at least 3 microns, thick.

In yet another aspect the invention provides a method of making porous anodic aluminium oxide films which method comprises providing a cell containing an electrolyte based on phosphoric acid at a concentration of 5-150g/l, at least one aluminium metal anode, the anode or anodes having an effective anodic surface area of at least 100 cm^2 and a thickness of at least 0.5mm, and a cathode, raising the voltage slowly to a desired anodizing value, passing a current through the cell at a voltage of 40-200V.

* * *

maintaining the elctrolyte temperature at a chosen value in the range 5-50°C until an anodic oxide film is formed at least 5 µm thick, and separating the film from a metal substrate on which it was formed.

The porous anodic aluminium oxide film may be used for some purposes still attached to the aluminium metal substrate on which it was formed. However, for many applications including filtration it is not attached to any substrate, in which case each major face has an area of at least 50 cm^2 and preferably of at least

* * *

100cm^2. The film is generally from 5 to 100 and preferably from 10 to 60, microns thick. Such films are self-supporting and capable of withstanding a fair amount of mechanical damage while still having interesting filter properties. The film contains a minor proportion of combined phosphorus derived from the anodizing electrolyte, effective to reduce or eliminate changes in pore size that might otherwise result from

hydration and swelling of alumina; this proportion typically lies in the range of 1-5 atomic % determined from phosphate ion concentration measured calorimetrically.

The method of forming these films involves anodizing with careful control of a considerable number of variables, as will now be discussed. The anodizing electrolyte contains from 5 to 150g/l, preferably from 20 to 70g/l, of phosphoric acid. Use of higher concentrations results in such rapid dissolution of alumina that it is difficult to form thick films. Use of lower concentrations results in uneven, uncontrollable and slow rates of film formation. The electrolyte may contain other solutes known to give rise to porous anodic oxide films, such as for example oxalic acid, or other compounds which reduce dissolution. And these additions may be beneficial to reduce chemical dissolution and permit the formation of thicker films.

Three major variables are electrolyte temperature, voltage and current density. The electrolyte temperature is preferably set at a value in the range of 10 to 40°C, preferably from 15 to 35°C. Above the top end of this range, dissolution of the anodic film is likely to be inconveniently rapid. Below 10°C, burning and low films growth rates are likely to be problems.

The voltage is preferably from 40 to 200 V. Anodizing below 40 V gives low film growth rate. Anodizing above 200 V is likely to be impossible due to dielectric breakdown. The voltage is preferably at least 60V.

The current density is preferably from 25 to 1000 A/m^2 of anode area. Current densities of 50 to 250 A/m^2 are generally chosen, due to the difficulty of dissipating heat produced at higher densities. Current density is a consequence of voltage and electrolyte concentration and temperature.

The current may be straight DC. Alternatively, various forms of biased, interrupted or pulsed current may be used, and maybe advantageous in achieving faster and more even film growth with reduced risk of burning. In order to avoid burning, it is necessary to raise the voltage or the current density slowly to the desired anodizing value. For example, the

maximum current density maybe set initially, and the voltage raised from zero at a rate of 0.02 to 0.5V/s to the desired value.

Anodizing is continued for a time to achieve the desired film thickness. Times in the range of 5 minutes to 240 minutes are likely to be sufficient for this method. Film growth rate is approximately linearly related to current density; for example, at 150 A/m^2 may imply a film growth rate of 0.5 microns per minute.

Electrolyte temperature has a major effect on the system, and is preferably held constant within 1°C or even less of the chosen value. This is not easy in a cell of commercial size, in view of the large amount of heat that is produced, and is preferably achieved by a combination of vigorous agitation and electrolyte recirculation. Stirring is liable to produce non-uniform film growth. Air agitation by tubes with holes bored in them is also not appropriate. It has been found that porous ceramic pots are a suitable source of air because the fine stream of bubbles can cause adquate electrolyte movement without blanking off areas of anode surface.

Cooling of electrolyte is preferably effected by circulating the electrolyte between the cell and one or more external heat exchangers. The extent of recirculation and cooling can readily be adjusted to remove the required amount of heat.

A problem frequently encountered in high voltage anodizing and referred to above is that of burning. At high current density any point weakness on the anode, in the form of low electrical resistance, may give passage to a high proportion of the available current and within seconds this point of low resistance will be subject to enormous current densities and the resultant high temperature will encourage the oxidation of the metal substrate. Burning may result in a region of thicker film or film of reduced thickness. In extreme cases the metal may be locally dissolved away. Amoung variables which may give rise to burning are low electrolyte concentration, low electrolyte temperature, the use of straight DC, and inade-

quate agitation. Attention to these variables should therefore help to minimize burning.

Another variable which appears to have some connection with burning is the aluminium ion concentration in the electrolyte, and this should preferably be in he range of 0 to 6 g/l. It is therefore useful to monitor aluminium ion concentration, which is readily done by observing its atomic absorption spectrum, and to take action when the concentration gets too high.

This invention is concerned with the commercial production of anodic oxide films on a substantial scale. We therefore specify that the anode has an effective anodic surface area of at least $100cm^2$, preferably at least $1000cm^2$. When a thin anode is sandwiched between two cathodes, both surfaces of the anode are counted in determining effective anodic surface area. The anode maybe unitary, or maybe divided into several separate pieces, the area of each piece being not important although it would generally be inconvenient to use small pieces below $100cm^2$ effective surface area. Although this is not preferred, a single cell may be divided by partitions into several regions each provided with an anode, and each region may have separate means for agitation and recirculation of electrolyte. Alternatively, it is possible to contemplate a unitary cell with a continuous anode in which a point on the anode has a residence time in the cell sufficent to coat it with an anodic oxide film of desired thickness.

The anode is at least 0.5nm or 1mm, and preferably at least 1.5mm, thick. The heat carrying capacity of such thick anodes helps to avoid burning.

Sharp edge or deep scratches on the anode can act as sites to initiate burning. However, bright rolled metal has been found perfectly adequate to avoid such problems. Care is also required with jigging, since capillary action between anode and jig can also initiate burning. To avoid initiation of burning by inclusions or alloying constituents, it is preferred to use aluminium metal of at least 99.5% purity. Commercial purity aluminium is suitable.

The nature of the cathodes is not critical. Generally conventional carbon cathodes will be used. To avoid the risk of edge effects, which again could lead to burning, the anode preferably extends in all directions beyond the perimeter of the cathode.

In the resulting anodic oxide films, the pores are generally spaced apart approximately 2.5nm per volt, and have a diameter of at least about 1ns per volt. In the film of this invention, the pores are preferably spaced from 0.1 or 0.15 to 0.5 microns apart, and preferably have a size (diameter) of at least 0.04 microns. Phosphoric acid anodizing always involves simultaneous film growth (at the metal/oxide interface), and film dissolution (at the oxide/electrolyte interface). This dissolution is concentrated round the pores and results in enlargement of the pores at their outer ends. In the limiting case, dissolution proceeds as fast as oxidation of metal, and film thickness remains constant on continued anodizing.

Having formed the anodized film, it is possible simply to dissolve away the remaining aluminium metal substrate, and recover a film with generally cylindrical pores extending straight through. A preferable technique involves separating the anodic oxide film from the substrate without destroying the substrate. This may be done by immersing the substrate with an adherent anodic oxide film in an electrolyte, anodizing it under a progressively reduced voltage until film detachment occurs, and removing the oxide film from the substrate. The electrolyte may be the same electrolyte as used for anodizing or a different one based on phosphoric acid or on some other electrolyte known to be capable of giving rise to porous anodic films. As mentioned above, a particular voltage reduction technique is described in EPA 178831. This results in a film with a system of larger pores extending in from one face and interconnecting with a system of smaller pores extending in from the other face. In this case, the "major face" referred to herein is that with the system of larger pores.

The following example illustrates the invention.

EXAMPLE

A cell was set up containing 1067 l of 40g/l H_3PO_4 as electrolyte. The anode was 99.99% aluminium sheet 1.5mm thick, precreated by mechanical polishing followed by electrobrightening, 1 sheets each 500 × 150 mm having an effective anodic surface area of $2m^2$. The anode was positioned between conventional carbon cathodes, such that the effective cathodic surface area to effective anodic surface area ratio was 3.66. The voltage limit was set at 160 V and the current density limit at 150 A/m^2. The current was increased from zero to full value over twenty minutes. Electrolyte agitation was effected by fine streams of bubbles from ceramic pots positioned below the interelectrode spaces. The electrolyte temperature was maintained at 25°C by recirculation of electrolyte between the cell and an external heat exchanger. After sixty minutes of anodizing at the full current a film thickness of 30±2 microns was achieved with a steady state anodizing voltage of about 140 V. equivalent to a pore spacing of 0.35 microns.

The film was separated from the substrate by a procedure involving a controlled voltage reduction from the final anodizing voltage to 0.3 V in the same electrolyte as anodizing, followed by chemical dissolution, rinsing and drying. A computer was used to control the power supply to effect voltage decrements of the greater of 0.3 V or 5% of the existing voltage. After each decrement, a monitoring system detected the maximum positive value of rate of change of current and caused the subsequent decrement when the rate of change of current fell to 50% of this maximum. On completion of this procedure the film was detached but not separated from the aluminium. Separation was brought about by immersion in 33% by volume H_3PO_4 at room temperature for 6 minutes followed by rinsing and drying.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A porous anodic aluminium oxide film having a major face with an area of a least 50 cm^2 and a thickness of a least 5 μm, the film material containing phosphorus derived from an anodizing electrolyte, wherein the film is separate from a metal substrate on which it was formed.

2. A film as claimed in claim 1, wherein the pores are spaced from 0.1 to 0.5 μm apart on the face.

3. A porous anodic aluminium oxide film having a major face with an area of at least 50 cm^2, the pores being spaced from 0.15 to 0.5 μm apart on the face and the film material containing phosphorus derived from an anodizing electrolyte, wherein the film is separate from a metal substrate on which it was formed.

4. A film as claimed in claim 3, having a thickness of at least 5 μm.

5. A film as claimed in claim 1, having a thickness of at least 10 μm.

6. A film as claimed in claim 1, wherein the film material contains 1-5 atomic μ of phosphorus.

7. A film as claimed in claim 1, wherein the pores have diameter of a least 0.04 μm on the face.

8. A method of making porous anodic aluminium oxide films which method comprises providing a cell containing an electrolyte based on phosphoric acid at a concentration of 5-150g/1, at least one aluminium metal anode, the anode or anodes having an effective anodic surface area of a least 100 cm^2 and a thickness of a least 0.5mm, and a cathode, raising the voltage slowly to a desired anodizing value, passing a current through the cell at a voltage of 40-200V, maintaining the electrolyte temperature at a chose value in the range 5-50°C

until an anodic oxide film is formed at least 5 µm thick, and separating the film the film from a metal substrate on which it was formed.

9. A method as claimed in claim 8, wherein the electrolyte temperature is maintained by recirculation of the electrolyte between the cell and an external heat exchanger.

10. A method as claimed in claim 8, wherein the current density is from 50 to 250 A/m^2 of anodic surface area.

11. A method as claimed in any one of claims 8 to 10, wherein the aluminium ion content of the electrolyte is from 0 to 6g/1.

12. A method as claimed in any one of claims 8 to 10, wherein the effective anodic surfaces area is at least 1000 cm^2.

13. A method as claimed in any one of claims 8 to 10, wherein the anode is of aluminium metal of least 99.5% purity.

14. A method as claimed in any one of claims 8 to 10, wherein there is used a single aluminium metal anode having an effective anodic surface area of at least 100 cm^2.

15. A method as claimed in any one of claims 8 to 10, wherein the node has a thickness of at least 1 mm.

16. A method as claimed in any one of claims 8 to 10, wherein the step of raising the voltage slowly is performed by raising the voltage at a rate of 0.02 to 0.5 volts per second.

17. A filter comprising a porous anodic aluminium oxide film as claimed in any one of claims 1 to 7.

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PATENT SPECIFICATION
1 532 112

[SEAL OF THE PATENT OFFICE, LONDON]

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YUKIMORI MOJI

IMPROVEMENTS IN OR RELATING TO HONEYCOMB STRUCTURES AND THEIR PRODUCTION

We, THE BOEING COMPANY, a Company organised and existing under the laws of the State of Delaware, United States of America, of P.O. Box 3707, 7755 East Marginal Way South, Seattle, Washington 98124, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method for obtaining environmentally durable honeycomb core structures and the product produced thereby. More particularly, this invention relates to a method for preparing a honeycomb core structure in which all surfaces are protected by the presence of an extremely adherent protective coating rendering the honeycomb core structures substantially less susceptible to corrosion, delamination and other environmentally and stress-induced failures.

A variety of methods are employed in the prior [ILLEGIBLE] to obtain aluminum and other metal honeycomb core structures. Heretofore, all such methods either require that the surface of the aluminum foil require that the surface of the aluminum foil utilized in the manufacture of the honeycomb core be bare and thereby susceptible to corrosion or that the core material, after bonding and expansion into the well-known hexagonal cell shaped core structure, be coated with a primer material such as by dipping or otherwise pouring the primer material into the interstices of the core. In the process in which primer is inserted into the core after the core is completed, a substantial amount of the primer is utilised in forming a meniscus at each node bond in the structure. For this reason an excessive amount of primer resin is used, which adds excessive cost and weight to the structure. In addition in order to assure the complete coating of all surfaces, a relatively thick and heavy coating of the primer substance is utilized. Frequently it has been found that such primed core materials have their weight raised to an excessive and unusable level by the presence of the primer substance. Less than adequate bonding at node bonds allowing environmental and stress degradation has been found to inhibit usage of prior art honeycomb structures and is not cured by application of primer resins to the interior of the honeycomb cells.

Other structures are known in which a chemical conversion utilizing amorphous chromate coating processes is used to prepare the surface of the aluminum foil prior to bonding and expanding it to the honeycomb structure. Such processes aid in the prevention of certain types of corrosion; however, they have been shown to be unsatisfactory in situations in which the honeycomb structure is exposed for long periods of time to marine atmospheres or other highly humid conditions. In addition, inadequate bonding at the node bonds between aluminum sheets has been found even with usage of the chemical conversion treatment.

Metal honeycomb structure which comprises the interior honeycomb portion is attached to face sheets by usage of an

adhesive. The resulting structure is light in weight, stiff and strong and frequently possesses good thermal and acoustical characteristics. Honeycomb core construction is widely used in aircraft construction and other transportation industries wherein a lightweight, but stiff and strong, structural component is necessary. The strength of such a composite structure relies upon the bond strength of the node bonds in the honeycomb structure itself and well as the bond strength of the core-face-sheet joint. Such joints must be of sufficient strength initially to meet the strength requirements of the intended purpose and, in addition, should be resistant to degradation suuch as by corrosion or hydration of the oxide at the adhesive-metal interface. The strength of the bond so formed is in part dependent upon the fillet size and depth into the honeycomb cell which the fillet attains. Due to surface tension and other phenomena associated with the flow of the adhesive into the honeycomb cell, the prior art structures and methods do not form the optimum fillet size and configuration for maximum bonding strength.

It is therefore an object of this invention to provide a method of producing an environmentally stable honeycomb structure. It is a related object to produce a honeycomb structure having protection against corrosion of the metal surfaces therein to enhance the usability of such honeycomb structures in humid atmospheres.

It is a further object of this invention to provide a method of constructing honeycomb structures in which strength of the between the honeycomb core and the facesheets utilized is enhanced. A related further object is to provide a method for forming a honeycomb structure in which the fillet size and configuration is optimized in the joint structure between the honeycomb core and the facesheets.

It is one specific object of this invention to provide a means for manufacturing aluminum honeycomb core structures in which the aluminum sheeting material utilized in forming the honeycomb structures is coated completely with a thin coating of a corrosion-resistant resin primer material placed over

an anodized, polymer-receptive oxide coating on the aluminum, and in which the further step of bonding the core materials and adhering facesheets to expanded core materials are carried out upon the primed surfaces of the aluminum honeycomb core whereby optimum adhesive fillet structure is formed to enhance the corrosion resistance and strength of the resulting honeycomb structure.

These and other objects of this invention as swell as certain preferred embodiments and products will become apparent from an examination of the following description of this invention taken in conjunction with the appended drawings.

Summary of the Invention

Accordingly, the method involved in this invention broadly comprises phosphoric acid anodization of the surfaces and then completely covering all surfaces ofthe metal foil utilized in forming a honeycomb structure prior to the application of adhesive materials at the necessary locations to form node bonds for the formation of the honeycomb structure with corrosion resistant coating. A thin, even coating, of organic protective material such as a paint primer or the like both forms the impervious protective covering to prevent corrosion of the metal and provides an improved base for application of the adhesive substance utilized in node bond formation and in adhering the facesheets to the end edges of the completed honeycomb core. Adherence to the metal by the primer in enhanced by anodization to form a polymer receptive surface.

Brief Description of the Drawings

Figure 1 is a production flow diagram schematically showing the succession of processing steps utilized in the preparation of honeycomb core structures in the prior art;

Figure 2 is a production flow diagram schematically showing a succession of processing steps utilized in carrying out the method of this invention;

Figure 3 is a chart showing an optimization test matrix for the anodization treatment used in preparation for application of primer to the aluminum foil;

Figure 4 is an enlarged, schematic, cross-sectional view of a honeycomb structure taken perpendicular to the axis of the cells of the honeycomb;

Figure 5 is a schematic representation of the stacked and bonding metal foil before expansion into the condition shown in Figure 4;

Figure 6 is a much enlarged, schematic view of a node bond of a honeycomb structure prepared according to the process of this invention;

Figure 7 is a schematic representation of the honeycomb-to-facesheet bond of the prior art; and

Figure 8 is a view similar to Figure 7, but prepared according to the process of this invention.

Description of the Preferred Embodiment

Referring to Figures 1 and 2, the schematic flow diagram of one prior art process used for preparing aluminum surfaces for honeycomb core manufacturing may be compared to the schematic flow diagram of the process of this invention. In each flow diagram it is seen that aluminum foil, as received, is first unrolled and subjected to a degreasing and alkaline cleaning process in preparation for the surface treatment. The alkaline cleaner is then removed in a hot water rinse. After the surface has been alkaline cleaned, the surface is subjected to, in the prior art process, a deoxidation and chromate conversion coating to stabilize the aluminum surface is subjected to an acid anodization step utilizing phosphoric acid as the electrolyte. In the event that the aluminum, as received, has a thick, adherent oxide coating or corrosion product, an aluminum deoxider or techant well-known in the art may be utilized to prepare the surface prior to the acid anodization step.

After surface treatment, the chemical agent used is rinsed from the aluminum foil and the foil is dried. In the process of

this invention, a primer such as an epoxy, a phenolic, an acrylic, a modified acrylic or other suitable resin is then applied on the prepared aluminum surface. The primer may be applied by use of any of the well-known primer application techniques including spraying, flow coating, electrophoresis or electrostatic deposition.

The primed aluminum surfaces are then cured. A suitable adhesive material such as a modified epoxy resin or other material widely used in the industry for adhesively bonding materials is applied at specified locations on the surface of the foil to form node bonds when the foil is stacked and expanded. The foil is then bonded, cut to the desired size and expanded to make a honeycomb sandwich structure. All surfaces of the metal used for the honeycomb in the process of this invention are thus covered with an environmentally stable primer substance, adhered to an oxide coating which resists corrosive attack, whereas the prior art process leaves exposed, environmentally unstable surfaces.

Details of the Invention

In carrying out the preferred method of the invention, the surface of the metal foil being utilized as the core material should first be subjected to phosphoric acid anodisation. In a continuous process, anodization in 10% to 30% phosphoric acid in a temperature range of 75°F. to 160°F. utilizing 5 to 30 volts potential for a period of 15 seconds to 4 minutes produces acceptable results. When utilizing shorter times periods, the higher range of phosphoric acid, higher temperatures and lower voltage produce most satisfactory results. The optimization test matrix shown in Figure 3 demonstrates that temperatures in the range of 130°F. to 160°F. with 30% phosphoric acid at 5 to 20 volts will produce a satisfactory product when the aluminum is anodized for 15 seconds to 2 minutes. Shorter time of anodization may be possible. For a continuous process it is necessary to have a minimum processing anodization time and, therefore, the test results of

Figure 3 were obtained. These samples were processed for the time period shown at the test parameters listed, followed by washing the surface of the test specimen, drying and then applying an adhesive tape produced by Minnesota Mining & Manufacturing (No. 250). In the evaluation procedure when the adhesive on the tape adheres to and remains on the oxide layer as the tape is peeled, superior bonding characteristics are indicated. In Figure 3, adhesive failure shown indicates that the adhesive remained on the tape when removed from the test specimen. Cohesive failure indicates that the adhesive from the tape adhered to and remained on the oxide layer as the tape was peeled from the specimen thereby indicating superior bonding characteristics are to be expected.

The evaluation test method was as follows. Three-by-six inch strips of anodized core foil (aluminum alloy 5052 H-38, a product of the Aluminum Company of America) were cleaned using clean gauze wet with acetone and thoroughly scrubbing the surface of the test specimen. The surface of the foil was then wiped dry using clean, dry gauze. A strip of one inch wide masking tape manufactured by Minnesota Mining & Manufacturing No. 250) which was less than six months old from date of manufacture was placed on the foil. The tape was pressed down using two passes of a 4.5-pound, rubber covered roller. The tape was removed in one abrupt motion perpendicular to the foil and the amount of adhesive left on the foil evaluated. This test conducted on standard core material (surface deoxidized, no further surface treatment) resulted in 100% adhesive failure. Tests on three commercially available, chemically treated core materials ("Dura Core" (Regd. T. M.), manufactured by American Cyamid Company, and "Hexcel (Regd. T. M.) CR/AL", both manufactured by Hexcell Corporation 11711 Dublin Boulevard, Dublin, California 94566) resulted in a high percentage of adhesive failure. A coating produced by low voltage anodization in phosphoric acid (anodization in 10% H_1PO_4 at 70°F. for 20 minutes at 10 volts) resulted in a failure mode which was 100% cohesive.

In an effort to obtain a continuous process for treatment of core material, the processing parameters were varied as shown in Figure 3. As a result the anodizing conditions employed to prepare aluminum foil surfaces for subsequent coating with corrosion inhibiting adhesive primer have been found to be within the following ranges:

TABLE I

	Temp (°F.)	Potential (Volt)	Time (Min.)	H_2PO_4 Concen.	Current Density (Amp/ft^2)
Usable Range	75–160	1–50	0.1 –30	5–50%	1–200
Preferred Range	100–140	5–20	0.15–3	10–40%	5–25
Most Preferred Range	130± 5	5–10	0.2 –2	30± 2%	15–22

The process of this invention has been shown to produce aluminum oxide coatings which, when a primer is applied, provide environmentally stable bonds superior to the state-of-the-art honeycomb core material. The test results indicate that substantially 100% cohesive failure will be observed rather than the adhesive failure encountered in the prior art procedures. Processing is equally usable on aluminum alloys and pure aluminum, however, the optimum processing parameters will vary with composition in a manner well within the skill or the art to determine. For example, higher processing temperatures are recommended for pure aluminum than for alloys.

In Figures 4–8 various aspects of the product produced by this invention are shown. In Figure 4 a view of a segment of a honeycomb core is shown looking axially through the honeycomb cell at a plane cut perpendicular to the axis of the cell. Aluminum foil walls 12 are formed into a substantially hexagonal structure having node bonds 14 at the interfaces of adjacent aluminum elements. As shown in Figure 5, wherein a plurality of aluminum foil elements are shown stacked and bonded together, but not yet expanded into the honeycomb structure, there is aluminum foil members 12a, 12b, 12c and

12d adhered to each adjacent aluminum foil element at node bonds 14. When expanded or pulled apart as shown by arrows 16 and 18, a structure such as that shown in Figure 4 results.

In Figure 6 a detailed schematic drawing very substantially enlarged is shown wherein the node bond structure itself is apparent. The aluminum foil 12a and 12b have an anodized oxide layer 20 on each side thereof upon which a layer of primer 22 has been placed. Adhesive 24 is shown in contact with the primer layer 22 on each of the two aluminum elements 12a and 12b. As can be seen from this schematic representation, a very thin layer of primer sūffices to protect the surfaces from corrosion.

In Figures 7 and 8 the effect on adhesive fillet size through the practice of this invention is schematically presented. In Figure 7 the prior art structure is schematically shown in which aluminum foil core material has a facesheet 32 attached by an adhesive 34. In the prior art the aluminum core 30 and 30a has an amorphous chromate chemical conversion layer 36 thereon such as is obtained by treatment with potassium dichromate or other well-known prior art surface treatments for stabilization of the aluminum surface. Since this coating 36 is an inorganic surface, it is inadequately wetted by the adhesive 34 and therefore a low fillet structure is obtained In distinction to this prior art, in Figure 8 a product produced by the process of this invention is shown. Core materials 12a and 12b have an anodized oxide 20 thereon, over which a primer such as an epoxy, paint-like material 22 has been placed. When printer is then contacted along the cell and edges with an adhesive, the adhesive tends to wet the surface of the primer and causes an extended fillet to form as is shown in Figure 8. The adhesive 46 forms a full fillet extending deep into the cells of the honeycomb structure. This adhesive is placed upon a facesheet 50 which has an anodized oxide surface 52 thereon to which primer coat 54 has been applied. The excellent adherence of the adhesive to both the honeycomb core material and the facesheet results in a bond superior to the prior art shown in Figure 7.

EXAMPLE I

Aluminum foil is received in coil form and continuously unrolled therefrom into a continuous processing apparatus. Both surfaces of the aluminum foil are subjected to a vapor degreasing with a solvent such as trichloroethtylene to remove lubricants from the rolling process and other deposits. An alkaline cleaner such as Turco (Regd. T. M.) 4215 produced by Turco Products, Inc., Division of Purex Corp., Ltd., Wilmington, California, is then utilized to thoroughly clean both surfaces of the aluminum foil. The aluminum foil is then thoroughly rinsed to remove the alkaline cleaner and transported to an anodization bath containing approximately 30% by weight phosphoric acid. An anodization potential is imposed with the aluminum film being the anode. A potential of 5 volts is utilized. The aluminum foil is then anodized for a period of approximately 30 seconds and removed from the anodization bath. The phosphoric acid remaining on the surface is removed in a water rinse and both sides of the aluminum foil are dried in hot air. An adhesive, corrosion inhibiting, epoxy primer is applied to a coating thickness of approximately 2/10 of one mil. The primer utilized is a modified epoxy primer produced by American Cyanimide Corp. under the trade designation BR 127. The primer-coated coil is then baked to cure the primer.

The adhesive required for the node bonds in the honeycomb is then applied by well-known techniques such as stencilling or printing, and the aluminum foil cut and stacked into position for curing of the adhesive. Depending upon the type of adhesive, the stacked foil is treated by heating or otherwise activating the adhesive for bonding purposes. The honeycomb core is then expanded in to the condition in which a substantially regular hexagon is formed as each honeycomb cell. A primed aluminum facesheet coated with adhesive is then applied to each side of the expanded core and hearted to bond the primed facesheet to the core with a strong fillet of adhesive extending into the honeycomb core cells. The finished

product resulting from this process is an environmentally stable honeycomb structure having substantially increased resistance to corrosion and hydration of the oxide surface and substantially increased bond strength both at the honeycomb nodes and at the facesheet-core bonding location.

The polymers which produce the type of primer coatings useful in this invention on aluminum surfaces are generally referred to as film-forming, organic polymers. Examples of such film-forming polymers are (1) poly-carbonate resins such as poly(bisphenol-A-carbonate); (2) acrylic resins such as copolymers with esters of acrylic and methacrylic acids, a specific suitable resin being a copolymer of methyl acrylate and methyl methacrylate; (3) epoxy resins such as glycidyl ether of disphenol A cured with triethylene tetramine; (4) polyimide resins; (5) polyurethane resins (6) hydrocarbon polymers such as polypropylene and polyethylene; and (7) phenolic resins.

The film-forming polymers used in this invention are preferably those which are dispersed in a carrier and may be applied by spraying, brushing or other well-known application means. The electrostatic deposition and electrophoresis techniques of application may also be utilized.

The preferred film-forming polymer is a heat-curing epoxy resin primer. The preferred epoxy resin primer is exemplified by an air drying-type, epoxy primer coating material which is manufactured by American Cyanimide under the trade designation BR 127. Other well-known primers and film-forming polymers may be substituted.

Adhesives which find use in forming the node bond structures in this invention include commercially available adhesive resins in thin film or sheet form or in a liquid sprayable or brushable composition. Examples of such adhesives are the high-bonding strength thermal setting resins such as the modified black copolymer epoxy and polyimide resins. Two resin compositions available in sheet form that have been found satisfactory for use with processes and apparatus of the present invention are the epoxy resins sold under

the product designation PL-729-300 by the B. F. Goodrich Chemical Company, Cleveland, Ohio, and the products designated AF-453, and AF-126 manufactured and sold by Minnesota Mining & Manufacturing Corporation, Minneapolis, Minnesota. These adhesives are conventionally sold in an uncured form for application by the user. It is sufficient that the adhesive be in a form which may be applied in the configuration necessary to form the honeycomb node bonds and be curable at conditions to which the stacked elements may be subjected. For example, adhesive in a sheet form may have portions thereof removed and laid down in sheet from serially upon each aluminum foil sheet during the stacking process. The adhesive preferably is of a type which will cure at an elevated temperature in the range of 200°F. to 400°F., however, adhesives curing at room temperature or slightly elevated therefrom may be used to form a strong bond between adjacent sheets of aluminum foil. Alternatively, the adhesive may be applied as by printing or other techniques well known in the art in the form of a liquid which similarly will cure at a temperature in the range of room temperature up to 400°F.

Although the present invention has been described with specific reference to preferred embodiments, it is to be understood that modifications and variations may be made to the invention within the scope of the appended claims.

WHAT WE CLAIM IS:—

1. A method of forming an environmentally durable, corrosion resistant honeycomb core structure from aluminum metal comprising the steps of:

preparing a polymer receptive oxide coating on both surfaces of an aluminum foil by anodization of said aluminum foil in phosphoric acid said anodization taking place at a temperature in the range of 75°F. to 160°F. 1 to 50 volts with phosphoric acid concentration of 5% to 50%;

apply a thin coating of an organic resin primer to said surfaces;

curing said primer to a coherent film to form a primed aluminum foil;

emplacing an adhesive on said primed aluminum foil, said adhesive being placed in locations chosen to form node bonds in a honeycomb structure;

stacking said foil;

curing said adhesive to from bonds between adjacent layers of primed aluminum foil to form a bonded stack of aluminum foil layers:

expanding said stack to form honeycomb cells therein forming a honeycomb core; and

bonding a face sheet to opposed end edge surfaces of said core with an adhesive which wets the surfaces of said primed aluminum foil to form fillets extending into said honeycomb cells;

whereby a honeycomb core panel assembly is formed having all metal surfaces of said core coated with corrosion resistant, organic coating to render said core environmentally stable and resistant to corrosion.

2. A method according to Claim 1 wherein said face sheets are primed on at least a core engaging surface therefor prior to assembly.

3. A method according to Claim 1 or Claim 2, wherein said polymer receptive coating is formed by anodization in phosphoric acid at the following conditions:

Temperature 130±5°F.
Potential (Volts) 5 to 10
Time 0.2 to 2 minutes
H_3PO_4 Concentration 30±2% byy weight
Current Density (amp/ft^2) 15 to 22

4. A method according to Claim 1, Claim 2 or Claim 3, wherein said adhesive bonding said face sheet to said core comprises an adhesive which wets the surface of said primer and extends in a fillet into said honeycomb core forming a

strong bond between said face sheet and said primed aluminum foil.

5. A method of forming a honeycomb core structure as claimed in claim 1 and substantially as described hereinbefore with reference to the accompanying drawings.

6. A honeycomb core structure produced by a method according to any one of Claims 1 to 5.

7. An aluminum honeycomb core structure comprising a honeycomb core formed of aluminum foil having a polymer receptive surface thereon and being primed over its entire surface prior to emplacement of node bond adhesive and stacking and bonding; and

at least one face sheet means adhered to one end edge surface of said core;

wherein said polymer receptive surface is an oxide coating formed by anodization of said foil phosphoric acid, said anodization taking place under the following conditions:

Temperature 75 to 160°F.
Potential (volts) 1 to 50
Time 0.1 to 30 minutes
H_3PO_4 Concentration 5 to 50% by weight
Current Density (amp/ft^2) 1 to 200

8. An aluminum honeycomb core structure substantially as described hereinbefore with reference to the accompanying drawings and as illustrated in Figures 6 and 8 of the accompanying drawings.

For the Applicants:
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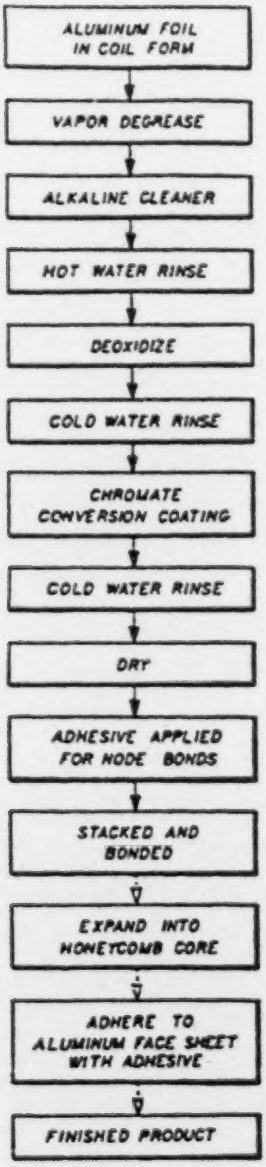
London, W.C.2.

1532112 COMPLETE SPECIFICATION

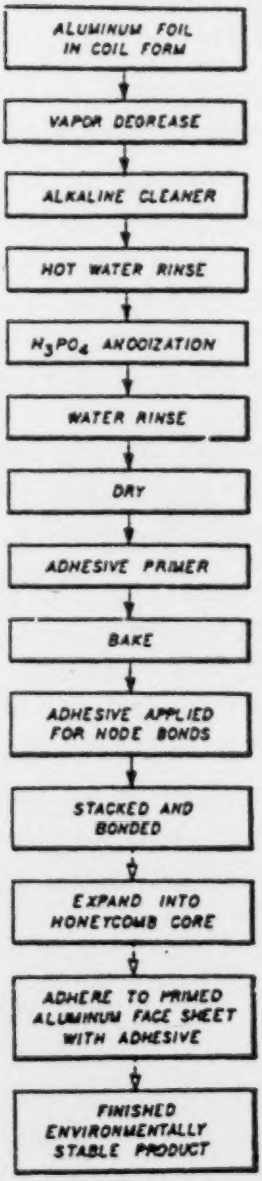
4 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 1



(PRIOR ART)

Fig. 1



(PRESENT INVENTION)

Fig. 2

1532112 COMPLETE SPECIFICATION

4 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 2

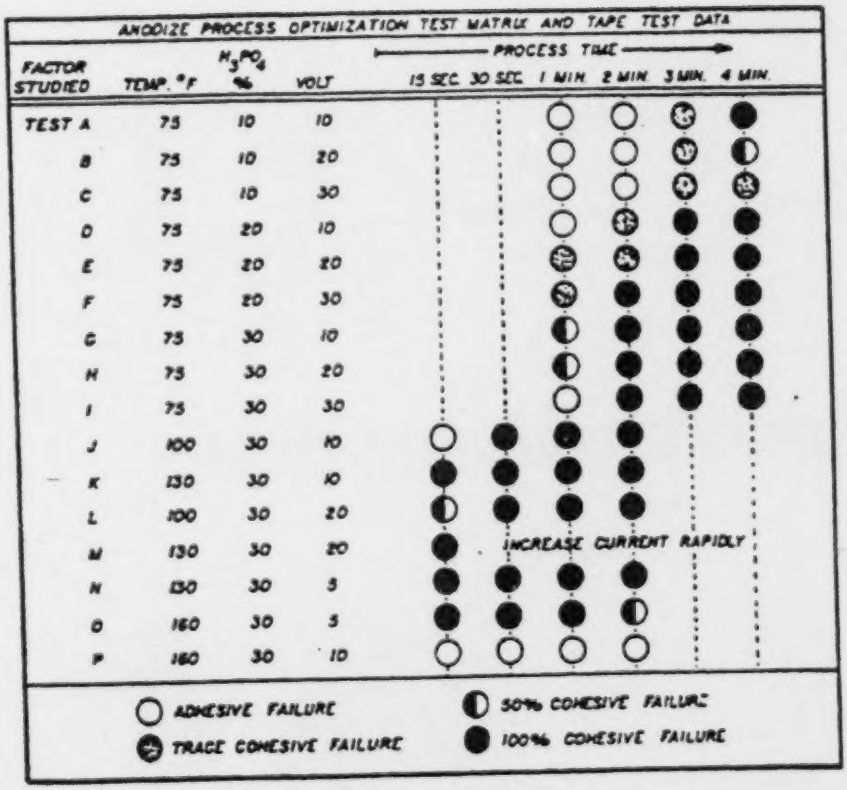
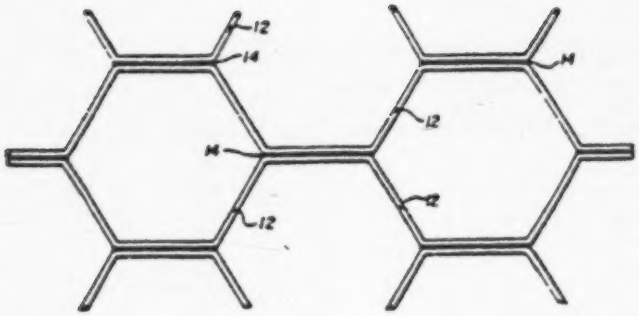


Fig. 3

1532112 COMPLETE SPECIFICATION
4 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 3

Fig. 4



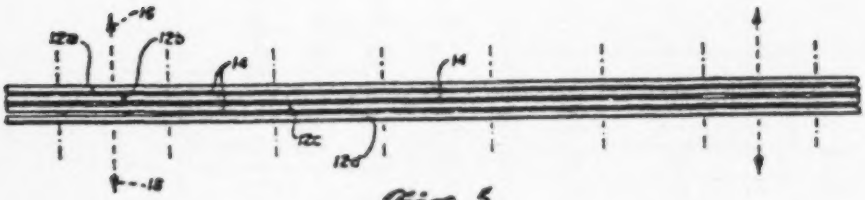


Fig. 5

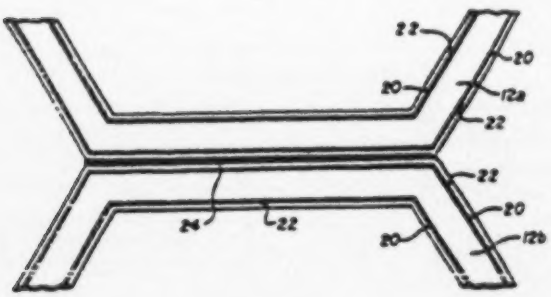


Fig. 6

1532112 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 4

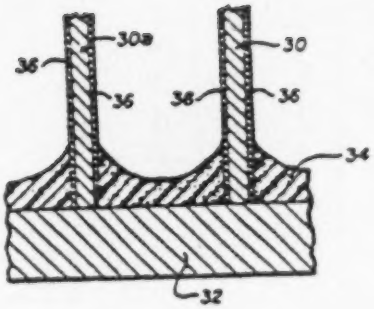


Fig. 7
(PRIOR ART)

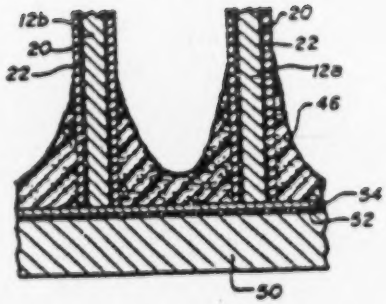


Fig. 8

VOTING SUMMARY OF THE FEDERAL CIRCUIT COURT OF APPEALS

CASES →	Markman (en banc)	Southwall	Vitronics	Bell & Howell	Fromson	Cybor (en bank)
DECIDED →	April 5, 1995	May 10, 1995	July 25, 1996	Dec. 5, 1997	Dec. 30, 1997	May 25, 1998
Archer	M (author)			M		M (author)
Bryson		M				C^1
Clevenger	M					M
Friedman			M			
Gajarsa						M
Lourie	M	M	M	M (author)		M
Mayer	C^2				M, C^1	D, C^2, AV
Michel	M	M (author)	M (author)	M		M
Newman	D				M (author)	D, C^2, AV
Nies	M					
Plager	M				M	C^1
Rader	C^2					D, C^2 (joins only part IV of Opinion)
Rich	M					M
Schall	M					M

M = majority

M (author) = authored majority opinion

D = dissent

C^1 = concurring

C^2 = concurring in the judgement only

AV = additional views